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military automation

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COMPONENT TEST AUTOMATION

Military production bottleneck caused by shortage of test personnel eased with automatic tests developed at Westinghouse Air Arm. .....Page 78

STUDENT ENGINEERING DEVELOPMENT

Critical shortage of scientists and engineers is met by Naval Air Missile Test Center Program which develops capabilities of local students ..Page 74

ALSO—Streamlining the Federal Supply System, Digital Techniques, Analog Computers, Printed Circuits, and IRE National Convention News.

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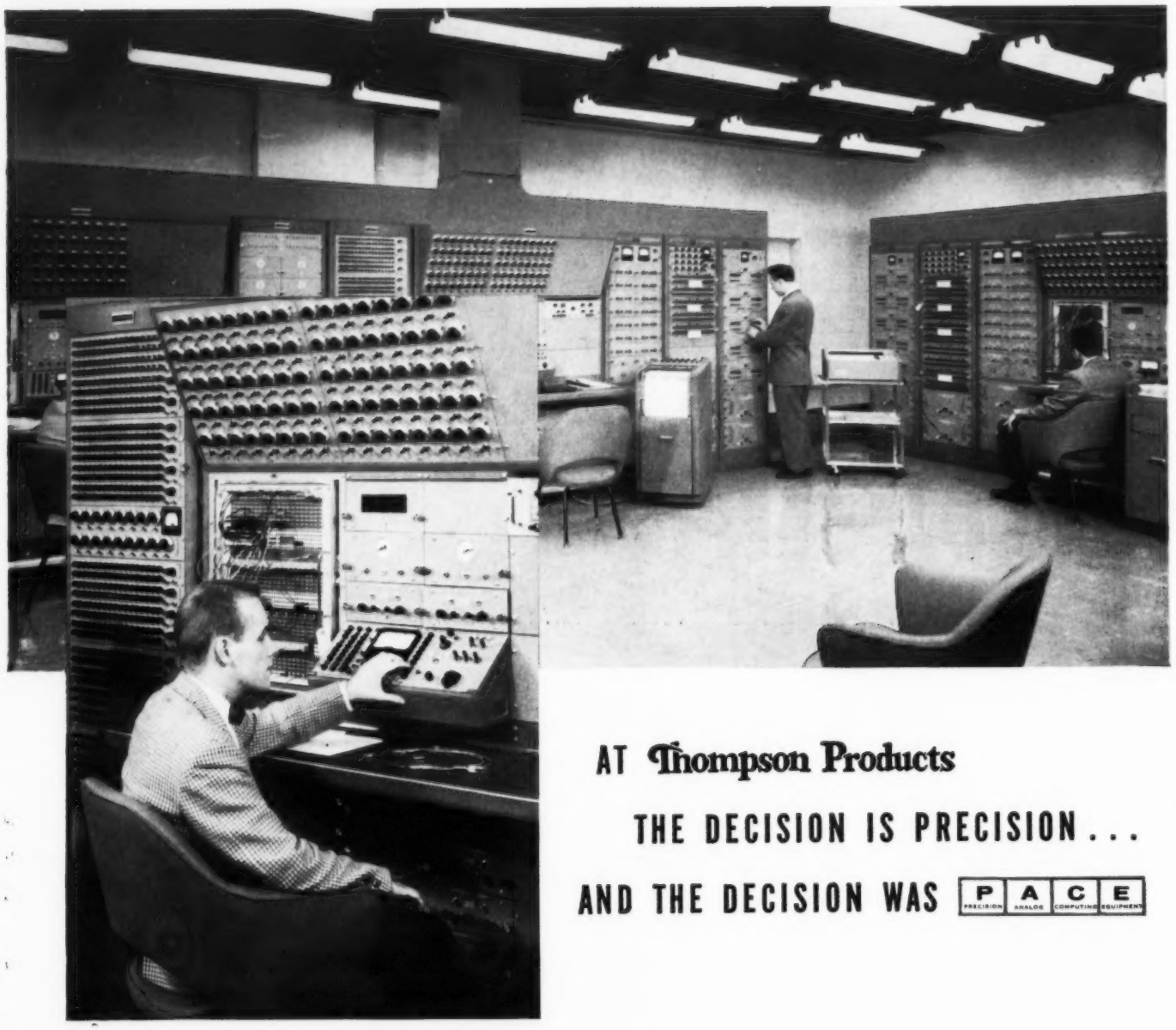

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In This Issue

We report editorially on significant military trends observed at the March IRE show in New York; also we comment on the military significance of the recent proposals for a nationwide H-bomb shelter construction program. Our feature articles report on: (1) importance and status of the Federal Catalog System, easily the largest single stock-control project in the world; (2) details of the Student Engineer Development program now in operation at NAMTC, Pt. Mugu, Calif.; (3) automation used in testing components for military equipment by the Westinghouse Air Arm; (4) additional Digital Techniques showing how multiplexing and counting are accomplished; (5) Analog Computer programming; and (6) commercial Printed Circuit techniques.

A few readers have asked why we included so much computer material in the first issue. The reason: first, the material you received in the previous issue is basic not only to computers as such, but also to computer-type circuits utilized in many classified military applications; second, unclassified discussion of these circuits can best be accomplished in connection with their use in digital and analog computers, and to a certain extent in training devices. For the same reason, we discuss in this issue the Vanguard satellite and printed circuits to provide basic missile information which has been released.

The value of operational trainers in providing safe and inexpensive exercise for pilots, navigators, gun crews, and radar operators is seldom appreciated, or their complex and often unorthodox principles rarely explained. NADAR, an airborne gunnery training aid, is described in this issue.

The supply of informative and interesting articles greatly exceeds the space available in each issue. A brief note on a postal card or on the margin of the MILITARY AUTOMATION postage-paid request card, indicating the subjects or type of articles you like, will help us in our selection.

Our biographical sketch this issue is of Mr. Ernest Goetz of the American Bosch Arma Corp.

Many expressions of congratulation and goodwill have been received on our first issue. We now settle down to a "steady strain on the line" and hope to merit your continued approval and support.

FIRST ISSUE PRINTING EXHAUSTED

The first issue of *MILITARY AUTOMATION* aroused so much interest that many individuals who did not receive that issue have requested copies.

Our original plans were to print and distribute 20,000. As the publication date approached, the print order was increased to 26,000. As of this writing our supply of the first issue has been exhausted. We are therefore sorry to advise that we will be unable to oblige those requests remaining unfulfilled. We are now processing recent subscriber requests so that our mailing lists for the second issue will be complete.

MA

VOL. 1, NO. 2

MARCH-APRIL 1957

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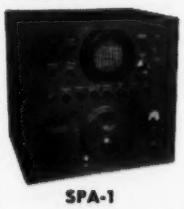

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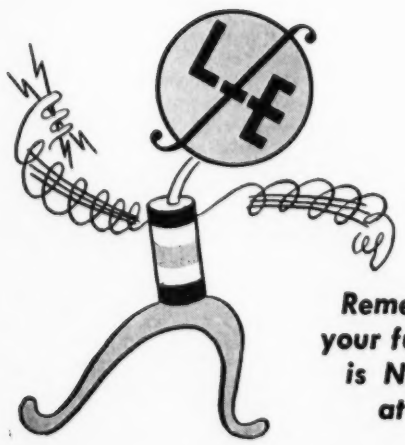

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Published bimonthly by Instruments Publishing Company, Inc., 845 Ridge Ave., Pittsburgh 12, Pa. Printed at 1600 N. Main St., Pontiac, Ill. Acceptance as Controlled Circulation Publication at Pontiac, Illinois, pending.

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(Commander U.S. Naval Reserve)

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Our Circulation Policy . . .

"This issue of *MILITARY AUTOMATION* is coming to you through courtesy of the firms listed on the inside back cover . . ." would be an appropriate announcement for a station break, if we were on the air.

In return for their support our advertisers expect us to deliver their message to a selected group of readers.

This selection is accomplished in two ways. First, applications for "qualified-reader" subscriptions are carefully screened to ensure that the applicant does in fact fall into one of the several categories listed on the opposite page. This work takes time and a thorough acquaintance with the industry. In case of doubt, the applicant is asked for further clarification by letter. We must have a personally signed request for subscription on file. Because of the very large demand for our magazine, some delay may occur and we hope you will be patient as we cope with the situation at this end.

The second method by which reader selection is accomplished is by the proper "care and feeding" of reader interest. Carefully prepared instructional articles encourage technical men to carefully read through each issue. Such a magazine also naturally begets confidence in the firms who support it. This interest and confidence is evidenced to the advertiser by the number and type of sales leads responding to advertisements, new product releases, and other news items which are printed.

This high reader inquiry rate which has long characterized our sister publications *INSTRUMENTS and AUTOMATION* and *INSTRUMENT & APPARATUS NEWS* is not a happy accident but the result of careful selection of circulation lists combined with conscientious and intelligent editing. We are proud that *MILITARY AUTOMATION* readers are also running true to form with an encouragingly high inquiry response.

* * *

We have had a number of requests for subscriptions from persons who recognize they do not presently fall within any of the "qualified reader" categories, but want the type of articles we are printing. Some are manufacturers of materials or basic components but not of military systems or equipments. These persons may request copies through our advertising representatives listed on page 62. Yearly paid subscription rates are $10.00 per year to U. S. citizens within the United States. No copies will be mailed overseas except to qualified readers attached to military overseas units.

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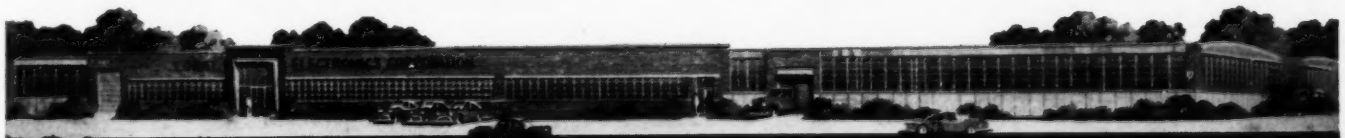

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For more information circle **4** on inquiry card.

In Preparation for future issues are articles on:

The Klystron (history and development), ballistic missile control, airborne searchlight control, simulation techniques used in training devices, operational testing of military electronic systems, humidity control and cathodic protection in the Reserve Fleets, airway control systems, military sonar equipment, fire control and industry, automatic assembly of electronic equipment, infra-red, radar, scatter communications, and guidance techniques, high-temperature and radioactivity-resistant components, reserve electronic training, magnetic amplifiers and magnetic UHF applications, waveguide transmission and traveling-wave-tube applications, and a survey of military electronics equipment.

Other articles in process include: digital computers; analog computer applications in military equipment and research; synchros and servo systems; transistors; atomic power; printed circuits; model basin, wind tunnel and test-range instrumentation; analog-to-digital converters; weapons systems analysis; rapid duplicating processes for shipboard and other military-command uses; and new techniques for increasing the efficiency of military supply.

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For more information circle **6** on inquiry card.

We heartily thank each of the following who took time to congratulate us on our first issue.

Publisher, MA:

I do not want to fail to join the long line of your friends who are wishing you success in your latest venture, MILITARY AUTOMATION.

I agree with you that there was a need for such a publication and I shall read it with much interest.

Herbert Ziebolz
Chicago, Ill.

Congratulations on publishing a very fine magazine and at the same time filling a void in the publishing field. Through the years your organization has been a pioneer in disseminating needed information. My very best wishes for your continued success.

Justin Oppenheim
Norden-Ketay Corp.

Editor, MA:

Congratulations on MILITARY AUTOMATION. I like issue number one. From the indications of the book it looks like it is the sort of periodical that has been vitally needed.

Harold Hechtman
Airborne Instruments Lab.

I am happy to hear about your new position as editor of MILITARY AUTOMATION. I am doubly glad that you are in that position. First, your background and experience will be helpful in presenting articles on pertinent military problems and second, your editorial viewpoints will assist in presenting this information in a logical and forthright manner.

Clayton O. Holt
Engineer, Bureau of Ships

Sincere congratulations, Commander Morrison! Of the Vol. 1, No. 1's I have seen, the January-February issue of MILITARY AUTOMATION is one of the finest!

Vernon H. Van Diver
Technical Writer

Send me MA for 1957. First issue just what I needed.

W. G. Brombacher, Consultant
Research & Development
National Bureau of Standards

Your initial issue is on my desk. There aren't enough adjectives, even with the aid of Roget's Thesaurus, to really gloat on this fine number.

I always say that anybody can get out a first issue. It's the next few ones that count . . . I anticipate lots of success in this new highly specialized undertaking.

Ralph L. Power
Littlerock, Calif.

Editor, MA:

Congratulations on first issue of MILITARY AUTOMATION which reached my desk this morning. I particularly liked the article on Modern Digital Techniques.

Samuel Freedman, Gen. Mgr.
Chemalloy Electronics Corp.

I would like to congratulate you on your first volume of MILITARY AUTOMATION. I read your magazine with a great deal of interest.

Thomas R. Hudson
Systems Coordinator

MA looks fine to me.

CDR R. G. Odiorne, USN
Electronics Officer
AstIndMan, San Diego,

I found your January-February articles extremely helpful—the article on "Modern Digital Techniques", Page 22, of such interest that I would like to keep it on permanent file. If reprints are available I would appreciate receiving one at your earliest convenience.

John P. Scheuer,
General Electric Co.

Your expression of interest is appreciated. Reprints of our articles are not available except on order for 100 or more, which will be furnished at our cost. We suggest you send us a subscriber qualification blank and hereafter receive your personal copy.

Let me take this opportunity to congratulate you and your associates for developing a very promising publication—MILITARY AUTOMATION.

Robert W. Brooks, Pres.
Computer Control Co., Inc.

Congratulations on a very fine first issue! I was particularly interested in "Modern Digital Techniques", by Milton H. Aronson and Martin L. Klein, but would like to point out one discrepancy in conversion from decimal to binary on page 23.

Garland E. Holt
Major USAF.

We want to thank the many readers who took time to write us about the error in method of conversion from decimal to binary in "Modern Digital Techniques" in our first issue. We are printing in full below the first such letter received, from Mr. R. A. Christie, Bell Telephone Labs., who presents the correct method. The binary answer must be written from right to left instead of vice versa.

Other corrections were received from Mr. William C. Schumacher, Ordnance Engineer; Messrs. John A. Szabo and Assefa Lemma, Stromberg-Carlson; Major Garland E. Holt, USAF; Mr. Leonard A. Majeske, Professional Engineer; Miss E. S. Bean, Engineer, Naval Electronics Lab. We also might note the following lyric complaint:

To double-dabble I was able,
To dabble-double caused me trouble.
27, 54, 108 and many more,
When the dabbling is all done
All are one, one, oh, one, one.

G. P. Sebru (Code 7124S)
U. S. Naval Research Lab.

Photo courtesy of Northrop Aircraft, Inc.

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Letters—*continued*

Editor, MA:

I would like to comment on the article "Modern Digital Techniques" by Milton H. Aronson and Martin L. Klein which appeared in the January-February issue of your magazine.

This was the most clearly written and easily understood explanation of binary numbers which I have seen and I look forward to the complementary article to appear in your next edition.

I believe that the authors made a slight error in their example of conversion from decimal to binary numbers (page 23) and as misfortune would have it, they used the number 27 in their example which reads the same from either direction in the binary system and hence the mistake was overlooked.

To illustrate this I would like to use the method as presented to develop the binary equivalent of decimal 35 and take the liberty of adding a column which I shall label correct development of the binary number.

Conversion of Decimal 35 to Binary Form

	Development as in Article	Correct Development
35/2 = 17 remainder 1, write	1	1
17/2 = 8 remainder 1, giving	11	11
8/2 = 4 remainder 0, giving	110	011
4/2 = 2 remainder 0, giving	1100	0011
2/2 = 1 remainder 0, giving	11000	00011
1/2 = 0 remainder 1, giving	110001	100011

Now binary number 110001 = 49 and 100011 = 35.

R. A. Christie
Bell Telephone Laboratories

Your new venture promises to help in meeting a pressing need—the need for a unitary reference covering new developments and components applicable to the instrumentation of Uncle Sam's fighting services, together with the technical background underlying their use.

I am particularly interested in computer technology, and welcome the series that begins with the article "Modern Digital Techniques". A few comments, however, appear to be in order here . . . .

Table 3 of the article lists "decimal", "binary", "trinary", and "octal" notation as "common number systems". I don't know what is common about "trinary" that could not be applied with much greater emphasis to the "duodecimal" system, which was not even mentioned. This system, while not at present affording any remarkable benefits in computer work so long as we are saddled with the decimal system in common usage, nevertheless has wide areas of superiority when compared with other existing or proposed numbering systems. "Twelve" and its powers have more usable and practical factors than does any other radix of manageable size; and circle measure in this system displays a distinct advantage in that 1/12 of a circle is a common angle (presently called 30° the sine of which is ½). 2/12 of a circle measures the internal angles of an equilateral triangle, 3/12 of a circle those of a square, 4/12 those of a hexagon, and 5/12 those of a dodecagon. The great utility of 12-part division of a circle or of a revolution is exemplified in the extremely versatile wafer switches we are accustomed to seeing in much of today's complicated circuitry.

For computer work, this radix could be implemented by utilizing two binary factors and one trinary (2x2x3

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- Inertial Guidance
- Installation
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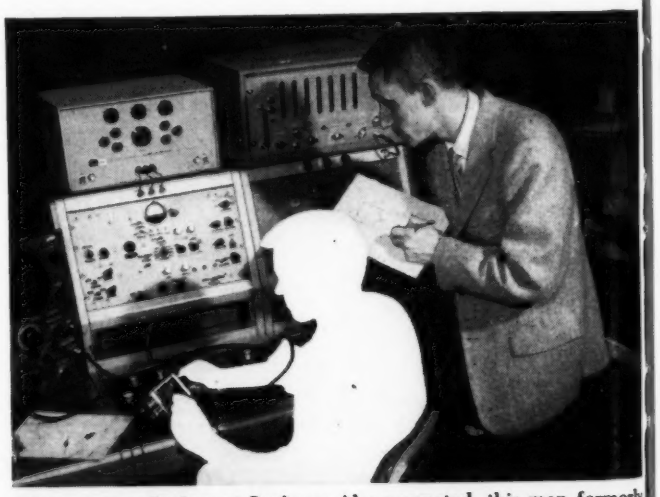
- Mechanical Design
- Optics
- Physics
- Power Supplies
- Programming
- Reliability
- Servo-Mechanisms
- Systems Planning and Analysis
- Technical Publications
- Test Equipment
- Transistors

Creative Mechanical Engineer: Previous to his latest promotion, this engineer worked on accelerometers, inertial devices, cooling units, servo-mechanisms and new techniques of gearing for subminiature computer units which will key future development of military weapons. Associates investigated new concepts in magnetic recording and number display devices, and read-out printers. *Do you belong here?*



Electronic Test Equipment Engineer: Also promoted, this man formerly provided instrumentation to test advanced airborne bombing and navigational computers. He analyzed test specifications, selected and designed test equipment; originated test procedures. Opportunities exist in systems, manufacturing, tool and cost engineering, product improvement, and automation research. *Do you belong here?*

Component Engineer: This man's job entailed the selection, evaluation, development, and application of electronic component parts, or building blocks, used in airborne bombing and navigational systems. Engineers and physicists will find stimulating opportunities here to engineer on precision analog components, gyros, accelerometers and analog-to-digital converters. *Do you belong here?*

Inertial Systems Engineer: Before his recent promotion, this man performed technical analysis, design and development of inertial guidance equipment. He specified and supervised development to determine the performance, configuration, design, and operation of inertial and missile guidance equipment. Opportunities for mathematicians, physicists, E.E.'s and M.E.'s. *Do you belong here?*

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Organized only 19 months ago, IBM Military Products Division has grown enormously. At Owego, N.Y., IBM designs and manufactures advanced airborne analog and digital computers for Air Force bombing-navigational equipment. At Kingston, N.Y., IBM builds the world's largest electronic computers for Project SAGE, part of our nation's giant defense net.

The electronic computer field offers engineers and scientists one of the best ground-floor career opportunities today. Economic experts rank the electronic computer in importance with automation and nucleonics in growth potential. Sales at IBM, the recognized leader in this fast-growing field, have doubled, on the average, every five years since 1930. Engineering laboratory personnel has quintupled in the past five years alone. $19,000,000 was spent on research and new product development in 1956.

As a member of IBM Military Products, you enjoy the stability and security of the IBM Corporation, plus the opportunity to progress in any other IBM division. The "small team" system assures recognition of individual merit. Promotions open up frequently through rapid expansion. Company-paid benefits set standards for industry. No wonder the rate of personnel turnover at IBM is less than one-sixth the national average!

For the facts about an engineering career with IBM Military Products Division, just write, outlining background and interests, to:

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Mgr. of Engineering Recruitment, Dept. 9104
International Business Machines Corporation
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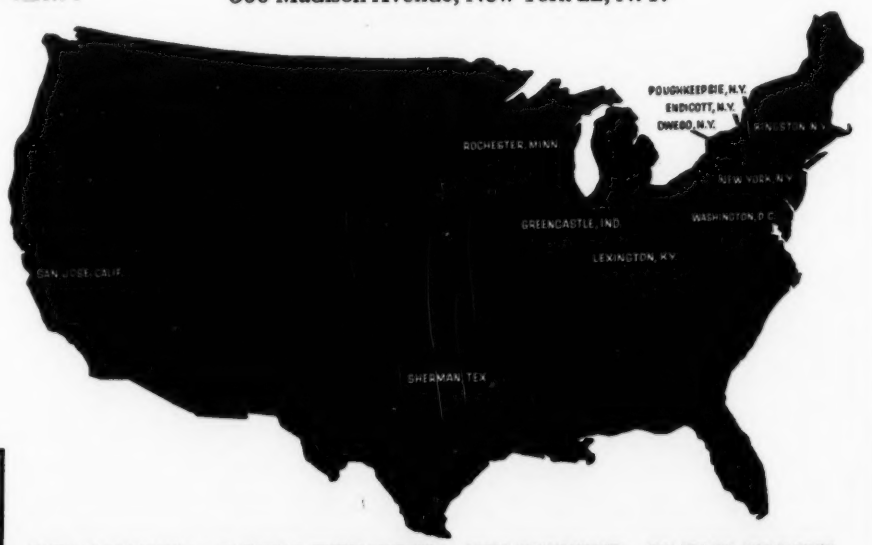
This map points out key IBM plants and laboratories, including the Military Products facilities at Owego and Kingston, N. Y. Limited openings available at many flight test bases and SAGE computer sites across the nation. IBM's 189 Branch Offices also offer opportunities for Customer Engineers.



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equals 12), obviating any "translation" such as we must now resort to with decimal notation. It is true that trinary stages are not in wide use (they are neither as well developed as are binary stages nor as readily applicable to decimal conversion), but with the investment of a mere fraction of the effort that now goes into binary-decimal and decimal-binary conversion this circumstance would be a thing of the past. If more information is wanted on duodecimal notation it can be obtained most authoritatively from the Duodecimal Society of America, 20 Carlton Place, Staten Island 4, New York, which will undoubtedly be delighted to acquaint you with the features of the system and provide you with literature on it.

The article also overlooks bi-quinary, two-out-of-five, and cyclic binary-decimal notations, but perhaps it was intended to discuss these later.

Returning to the contents of the article, the "Double-Dabble" system. The right answer came out in the article only because "11011" reads the same forwards and backwards.

I prefer the following routine because the significance of each derivation is obvious at the time it is made and there are no "leftovers" to create confusion. For example, using "27" as in the article:

1. By inspection, 27 is an odd number. Equate this to 26 plus 1.
2. Place the "1" in the units' place of the binary result.
3. Divide the "26" by 2. The result is 13 (again odd).
4. Equate 13 to 12 plus 1; place the "1" in the twos' place of the binary result (to the left of the "1" previously derived).
5. Divide the "12" by 2. The result is an even number (6), so that a zero goes in the four's place to the left of the two "1's" already determined.
6. Divide the "6" by 2, giving "3", which is equated to 2 plus 1.
7. The "1" is inserted ahead of the "011" already computed.
8. The "2" is divided by 2, giving the final "1", which becomes the first digit of the answer.

Obviously, every division by 2 of the quantity being dealt with raises the order of the powers of 2 being extracted, and every time a binary "1" is removed it represents a power of 2 corresponding to the number of divisions that have already been performed (e.g., 0, 1, 3, and 4 in the example, representing 2^0, 2^1, 2^3, and 2^4, the sum of which is 27).

The authors' conversion from binary to cyclic binary, while workable, is far too cumbersome. It is much easier to remember that any digit in the original binary number that is preceded by a "1" is exchanged for its ones complement.

Also, in discussing the 1, 2, 4, 7 system, the remark is made that "only two 1's are used to express any number". The authors should have said that "*not more than*" two 1's are needed to express any digit".

William C. Schumacher
Ordnance Engineer

Your discussion is instructive and ably presents the importance of the duodecimal system. Our treatment included the trinary system only as an example that any number could be used as a base for a number system. As we do not have space for an exhaustive treatise on all types of number systems, we omitted several types of notation, as you noticed.

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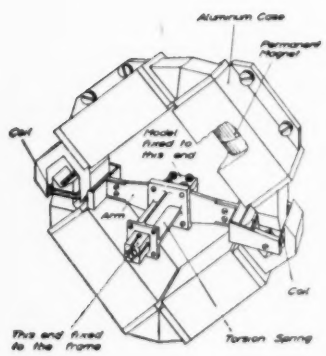

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MA

IRE Impressions

Equipment, components and techniques designed for military end use or production dominated the IRE Show in New York. Few of the 840 exhibitors did not show some development or product specifically pitched toward a share of the $36-billion 1958 defense budget. (Many of these will be treated in the detail they deserve in later issues of *MILITARY AUTOMATION*.)

Many observers commented on the lack of startling disclosures in either the papers presented or in commercial developments. Some went so far as to venture an opinion that the policy against using Department of Defense funds for basic research might be at fault. Whether this is true might be questioned on the grounds that sufficient time has not elapsed since that announcement to show an effect in output. However, any over-all diminution in basic research is certain to seriously handicap our military readiness in the long run.

Miniaturized components, circuits and equipments made a striking contrast with giant waveguides and klystrons designed for high-power scatter communications equipment.

Actual numbers of transistors used in military equipment is far below that of vacuum tubes, but development emphasis is on solid-state applications, printed circuitry and miniature components. New plastic-metal laminations, suggestions for standardization of printed-circuit assembly techniques, and specialized equipment for printed-circuit fabrication were featured. An indication of the extent to which the miniaturization trend may carry the industry was given in a paper on "Microminiaturization" by Dr. Cledo Brunetti. He stated that the increasing complexity of electronics and control equipment demands an ever increasing volume and weight carried by planes and ships. This trend can and must be reversed by miniaturization. Solid-state devices used with tubes and other conventional passive components give hints of advantages to come. Each equipment must be stripped to bare essentials, in the light of the capabilities and requirements of the new solid-state devices, and all unnecessary components eliminated. Brunetti cited the transistor itself as having a volumetric efficiency of less than one thousandth of one percent because it consists of a very small active junction encased in a much larger amount of inert material. Solid-state circuits—defined as "three-dimensional networks of metallic, inter-metallic and insulating materials which transmit and control currents in the same manner as combinations of ordinary electronic components"—were proposed as the solution to ultimate miniaturization and also to increase reliability through the elimination of unneeded materials. The human optical system was cited as a natural example of micro-miniaturization which we might some day approach in efficiency.

Air traffic control problems were emphasized not only in the exhibits of computers, readout systems and display tubes, but also in a wealth of papers covering the multipurpose 100-kc radio navigation system, final approach systems requirements at high landing rates, and a 1000-mc instrument landing system.

Improvement of reliability received much attention, being the theme of two sessions. The first stressed the Air Force Reliability Program, an attempt to engineer missiles system reliability; the second stressed a reliability program in design of a computer system. Techniques for improving reliability through tests, sampling and analysis were given at a later session.

Magnetic and paramagnetic properties of solids as applied in magnetic amplifiers, microwave switching elements and detectors were exhibited.

The ultra-precise timing achieved by the National Co. Atomichron and by the Standard Electronics Research MASER (seen at 3rd Int. Automation Exp.) will be of great importance in improving the accuracy of missile guidance. Giant waveguides, klystrons and antenna components indicated the impetus being given to scatter-propagation communication techniques. Travelling wave tubes and amplifiers were also exhibited by several manufacturers.

Test equipment is more specialized and shows a trend toward automation, particularly when designed for use in military maintenance. This trend is expected to continue.

Automatic iris control for TV cameras used in areas having great variation in illumination was shown by one manufacturer, while a 1/2″ vidicon tube was shown by another. These improvements should encourage further military application of closed-circuit TV.

H-Bomb Defense

Mr. W. E. Strope, of the Naval Radiological Defense Laboratory, San Francisco, an internationally respected authority on the military effects of nuclear bombing, is quoted in connection with the laboratory's request for a Congressional expenditure of 15 to 20 billion dollars to build a national system of underground shelters against an H-bomb attack.

It is estimated that if suitable shelters were available, 99 out of every 100 U. S. citizens could survive an all-out H-bomb attack.

The interest of Mr. Strope, who specializes in the military aspects of nuclear weapons, in a subject commonly thought to be the domain of Civil Defense is significant. As Russia approaches equality with the U. S. in numbers of H-bombs and the means to deliver them, the relative vulnerability of the two countries to nuclear attack becomes the critical factor. If nuclear war were to start in the immediate future, our cities would have substantially the same vulnerability as Hiroshima twelve years ago. Plans for on-foot evacuation of major population centers into open areas where no food, water, sanitary facilities, nor shelters yet exist are all that Civil Defense has been able to accomplish on the little money that it has been allotted. Little headway in dispersion of industry has been made.

No other solution attainable within the next five years would contribute more to our ability to wage an all-out war, and so to discourage foreign attack. Although the costs are staggering at first sight, it is a program comparable to the Federal Road System already under way. Also, some self-liquidating features might be worked out. We suggest the possibility of building underground parking lots in downtown business and other congested centers. Municipal and other office buildings might be constructed underground for quick conversion to bomb shelters.

Mr. Strope states that shelter requirements fall into four types:

Class I—For rural areas with maximum resistance only to gamma radiation. Cost, about $30 per person.

Class II—For residential and light business areas, where shelter must also resist fires. Cost, about $40 per person.

Class IIIA—For business areas with less dense population. Cost, about $60 per person.

Class IIIB—For densely populated downtown city areas, capacity 1000 persons per shelter, with 100 persons per room. Cost, $300 per person.

Minimum Shelters

Minimum requirements for shelters are structures of No. 1 corrugated steel surrounded on all sides and top by at least three feet of earth. Concrete and fiberglass are also possible structural materials. Shelters should be equipped with food supplies for two weeks, a bed for each person, periscopes, radiac detectors, emergency power, chemical sanitary facilities, a radio receiver, and first aid supplies.

Dr. Paul C. Tompkins, the Laboratory's scientific director, stresses the urgency of the program.

"If we can get started . . . this year, it can be completed in five years."

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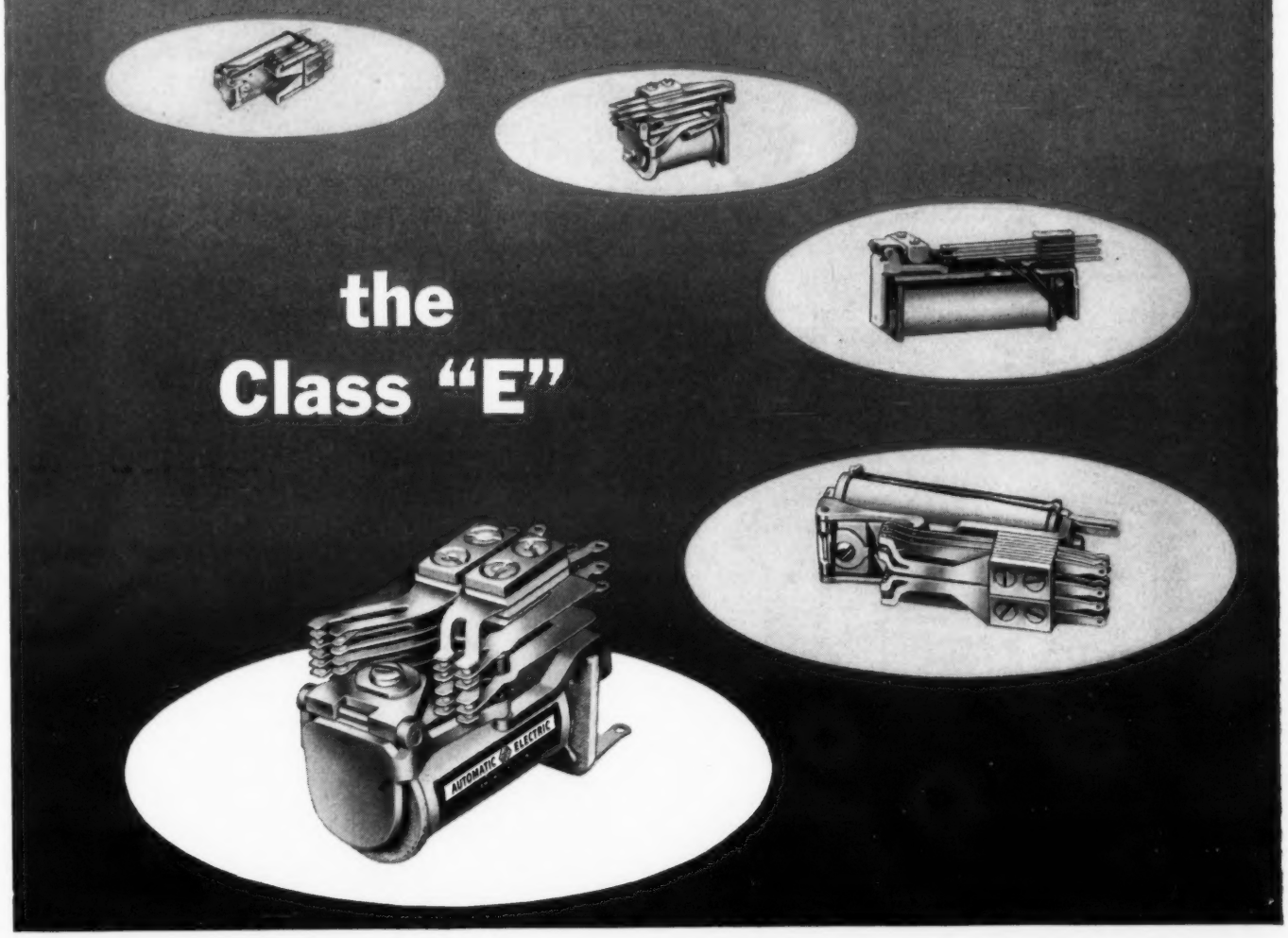

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- heavy thickness armature arms (previously available only in larger relays).
- heavy-duty backstop that won't wear out.
- adequate terminal clearances for easy wiring.
- long-life, lubricant-retaining bearing also allows for an easy check of the heelpiece airline setting, without disturbing the adjustment.
- fully independent twin contact springs.
- sturdy, strain-relieved heelpiece insures stability of adjustment.

For more information, call or write Automatic Electric Sales Corporation, Chicago 7. *In Canada:* Automatic Electric Sales (Canada) Ltd., Toronto. *Offices in principal cities.*

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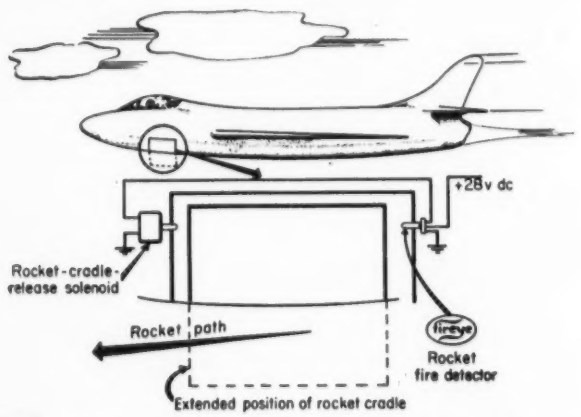
Rocket Fire Detector

CAMBRIDGE, MASS.—Engineers at Electronics Corp. of America have developed an electronic rocket fire detector for use with jet fighters designed for submerged rocket stowage (rocket cradled within the aircraft fusilage). In such cases, the rocket firing mechanism must extend the rocket cradle, fire the rocket, and return the cradle to its position within the plane—all within a matter of seconds.



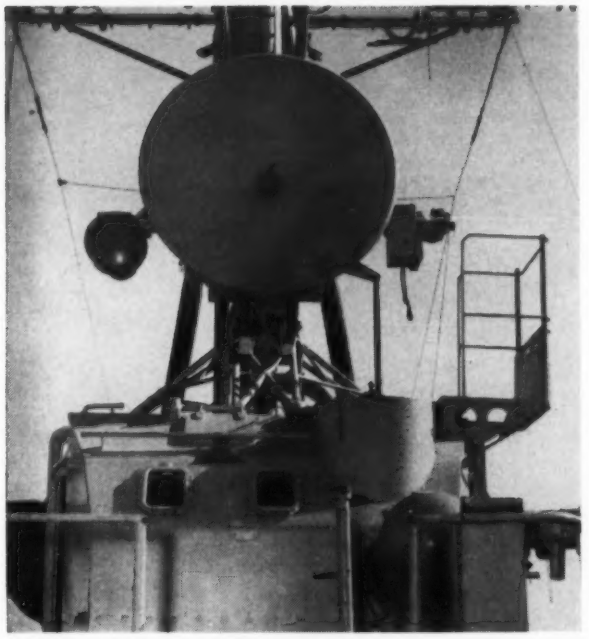
The rocket may be accidentally fired within the plane (possibly by enemy gunfire) or may hang fire and be drawn back into the plane. If this happens, the terrific heat generated. up to 3000°F, will likely destroy the airplane within a few moments. Tests have shown that even a small rocket will burn through aircraft structure in less than 4/10 sec.

New Fireye Rocket Fire Detector spots the rocket flame at the instant of ignition and actuates a release mechanism that throws the rocket clear of the plane, all within a safe time interval. Effectiveness depends on the principle of visual fire detection, using infrared radiation sensitive photoconductive cells whose response time is measured in microseconds. Single 5″ high, 1″ diameter, cylindrical unit will safely monitor an entire rocket compartment.

For more information circle **101** on inquiry card.

Radar Guidance

NEW YORK, N. Y.—Radar guidance equipment designed for the Terrier Missile system installed aboard the U. S. S. Gyatt, the U. S. Navy's first guided-missile destroyer, combines for the first time



Terrier Radar

a gunfire control system with radar guidance equipment. Terrier is designed to intercept aircraft under all weather conditions by night or day. When approach of unidentified plane is indicated on the radarscope, certain signals are generated which identify the plane as friend or foe. If enemy, the radar continues tracking the target, and relays information to the missile launching computer for firing. Missile then shoots into the radar beam and is guided by the radar to intercept and destroy its target. Guidance equipment is built by Reeves Instrument Corp., subsidiary of Dynamics Corp. of America.

For more information circle **102** on inquiry card.

Ordnance Data

DETROIT, MICH.—RCA's Bizmac system at Headquarters of Tank-Automotive Command opens way for sharp cut in world-wide stocks of spare parts in next two years. The $4.1-million electronic data processing system, said to be world's largest, has reduced months of paper work to minutes of pushbutton operation. It keeps track of more than 100,000,000 facts about the Army's vast inventory of tank and automotive spare parts throughout the world—everything from nuts and bolts to entire engines. Bizmac maintains up-to-minute information about what supplies are on hand, how fast they are being used, what has to be ordered and in what quantity. Bizmac can (1) take inventory, catalog, spare parts, prepare manuscripts for catalogs, forecast supply requirements and produce budget summaries. (2) complete, in forty-eight hours, an inventory procedure that once took up to three months, (3) handle in one-half hour a price calculation that used to take a clerk five weeks of steady work, (4) record information on magnetic tape and read from tape 1,700 words per second (it could finish Tolstoy's "War and Peace" in about five minutes), (5) store on a single 10½-inch reel of magnetic tape as much information as was previously held in ten file shelves, (6) print shipping orders and other business paper work at a speed of 600 lines a minute, (7) reduce by 85 per cent, over the next year, OTAC's visible records which are now on some 10,000,000 file cards, punched cards, metal plates and hand written sheets.

At this rate it will pay for itself, many times over, every single year.

For more information circle **103** on inquiry card.

Rocket Test Sled

BRISTOL, PA.—Rocket test sled is designed to check canopy and seat ejection equipment for the McDonnell F101A aircraft. Constructed in accordance with aircraft techniques, sled uses aluminum alloy material and incorporates a portion of the F101A fuselage including complete cockpit area and canopy.

Seat Ejector Test

Power is supplied by fourteen solid-propellent rockets rated at 11,000 pounds thrust each. Sled deceleration is by water scoop. Test runs have been completed at the supersonic track at Edwards Air Force Base, Calif., under supervision of Hunter-Bristol Corp., builders of the sled.

For more information circle **104** on inquiry card.

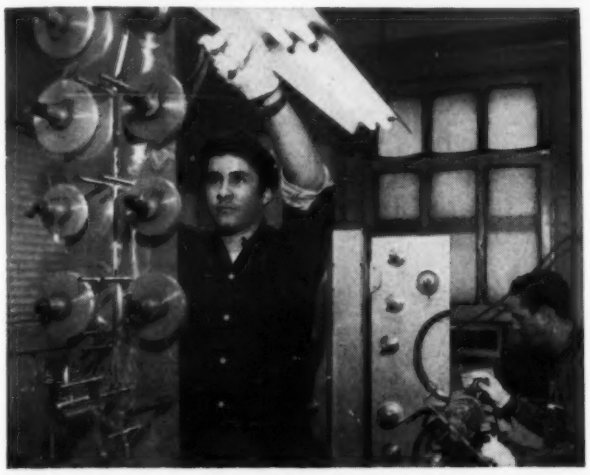
Guided Missile Reliability

PT. MUGU, CALIF.—The annual Joint Military-Industry Guided Missile Reliability Symposium will be sponsored this year by the Office of the Assistant Secretary of Defense for Engineering and the Chief of the Bureau of Aeronautics, Navy Department, and will be held at the Naval Air Missile Test Center, Point Mugu, California, November 5 and 6. November 7 will be reserved for visits to the Center's technical and operational areas. Persons desiring to attend must have a Secret security clearance and should make known their plans by August 15 to Commander, USNAMTC, Reliability Symposium, Code CEN-1, U. S. Naval Air Missile Test Center, Point Mugu, Calif.

Individuals and organizations wishing to present papers should submit an abstract of approximately 250 words no later than June 15, 1957. It is desired that contributions bear a security classification not higher than Confidential and that abstracts be Unclassified, if possible. Papers are invited on the following subjects: Component Problems, Mathematical Treatment, Plant Techniques, and Testing Techniques.

Capacitor Specialists

NEW YORK, N.Y.—The military need for high-quality precision components, often produced in small lots, is offering an opportunity to smaller firms who



Operations in the winding room where capacitor production begins.

are able to meet such requirements.

Larger manufacturers, dependent on mass production and semi-automatic procedures, often find it impractical and uneconomic to set up the specialized production lines required for ultra precision components used in missile-guidance systems or miniaturized and printed-circuit applications, which also must meet military specifications.

Thus today we find a new group of manufacturers specializing in high-precision components manufactured to customer requirements and featuring indi-

Close-up of an assembly bench.

vidual test and calibration of each component. An example of such firms is Electronic Fabricators, Inc. During four years of production it has demonstrated an ability to produce capacitors to the tolerances and specifications set by the customer. Company provides 100% testing before shipment, and applies specialized skills derived from its own experience to insure that customers receive orders within deadlines.

For more information circle **105** on inquiry card.

Satellite Timer

CLEVELAND, OHIO.—A program timer for the artificial satellite's launch vehicle requires extreme accuracy of timing. A transistorized secondary frequency standard is being used to obtain near-perfect accuracy.

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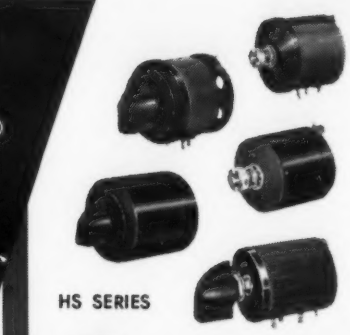
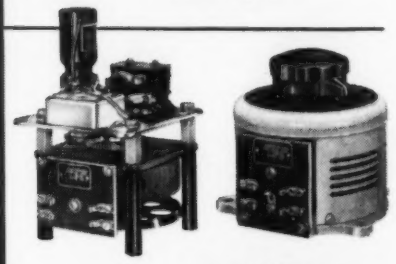
SINGLE PHASE														
28	400/800	0–28	2.0	.056	Open	3HS02UK	Knob	0.5	0.9					
28	400/800	0–28	4.0	.112	Open	3HS04UK	Knob	0.8	1.2					
120	400/800	0–120 or 0–140	1.0	.14	Open	1HS01UK	Knob	0.9	1.3					
120	400/800	0–28	2.6	.073	Open	1RHS03UK	Knob	0.6	1.0					
120	400/800	0–120 or 0–140	3.0	.42	Open Square Frame	1HMS03UK	Knob	2.4	2.8	DM1HMS03U	28 Volt D-C	60	4.5	5.1
										AM1HMS03U	120 Volt A-C, 400 Cycles	60	4.5	5.1
120	400/800	0–120 or 0–140	7.5	1.0	Open Square Frame	1HMS07UK	Knob	3.4	3.8	DM1HMS07U	28 Volt D-C	60	5.5	6.1
										AM1HMS07U	120 Volt A-C, 400 Cycles	60	5.5	6.1
120	400/800	0–120 or 0–140	15.0	2.1	Open	1HL15UK	Knob	11.4	14.0	DM1HL15U	28 Volt D-C	60	13.2	16.2
										AM1HL15U	120 Volt A-C, 400 Cycles	60	13.2	16.2
240	400/800	0–240 or 0–280	3.0	.84	Open Square Frame	2HMS03UK	Knob	3.4	3.8	DM2HMS03U	28 Volt D-C	60	5.5	6.1
										AM2HMS03U	120 Volt A-C, 400 Cycles	60	5.5	6.1
240	400/800	0–240 or 0–280	9.0	2.5	Open	2HL09UK	Knob	12.8	15.4	DM2HL09U	28 Volt D-C	60	14.6	17.6
										AM2HL09U	120 Volt A-C, 400 Cycles	60	14.6	17.6
THREE PHASE														
240	400/800	0–240 or 0–280	3.0	1.5	Open	2HMS03UK-3Y	Knob	7.6	8.5	DM2HMS03U-3Y	28 Volt D-C	60	9.3	10.5
										AM2HMS03U-3Y	120 Volt A-C, 400 Cycles	60	9.3	10.5
240	400/800	0–240 or 0–280	7.5	3.6	Open	2HMS07UK-3Y	Knob	10.6	11.6	DM2HMS07U-3Y	28 Volt D-C	60	12.3	13.6
										AM2HMS07U-3Y	120 Volt A-C, 400 Cycles	60	12.3	13.6
240	400/800	0–240 or 0–280	15.0	7.3	Open	2HL15UK-3Y	Knob	34.5	41.0	DM2HL15U-3Y	28 Volt D-C	60	38.0	45.0
										AM2HL15U-3Y	120 Volt A-C, 400 Cycles	60	38.0	45.0
480	400/800	0–480 or 0–560	3.0	2.9	Open	4HMS03UK-3Y	Knob	10.6	11.6	DM4HMS03U-3Y	28 Volt D-C	60	12.3	13.6
										AM4HMS03U-3Y	120 Volt A-C, 400 Cycles	60	12.3	13.6
480	400/800	0–480 or 0–560	9.0	8.7	Open	4HL09UK-3Y	Knob	39.0	45.5	DM4HL09U-3Y	28 Volt D-C	60	42.5	49.5
										AM4HL09U-3Y	120 Volt A-C, 400 Cycles	60	42.5	49.5



HS SERIES



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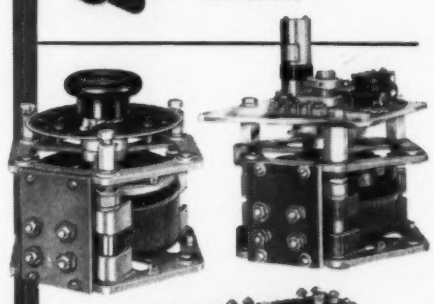

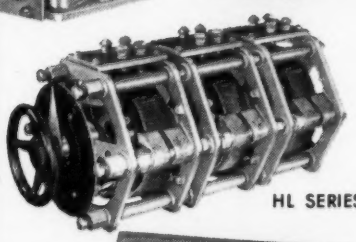

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AS SMALL AS 3/4" x 3/4" x 1 3/8"
AS LIGHT AS 1 1/4 OUNCES

"TOM THUMB"

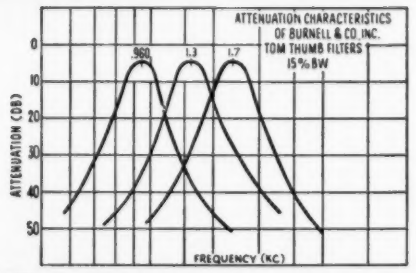
CHAN. #	FREQ.	IMP. 100K P/N	B. W.	SIZE	WT.
1	400 cps.	S-60001	±7½%	¾ x 1½ x 2¼ H	4 oz.
2	560 cps.	S-60002	±7½%	¾ x 1½ x 2¼ H	4 oz.
3	730 cps.	S-60003	±7½%	¾ x 1½ x 2¼ H	4 oz.
4	960 cps.	S-60004	±7½%	¾ x 1½ x 2¼ H	4 oz.
5	1300 cps.	S-60005	±7½%	¾ x 1½ x 2¼ H	4 oz.
6	1700 cps.	S-60006	±7½%	¾ x 1½ x 2¼ H	4 oz.
7	2300 cps.	S-60007	±7½%	¾ x ¾ x 1⅜ H	1¼ oz.
8	3 KC	S-60008	±7½%	¾ x ¾ x 1⅜ H	1¼ oz.
9	3.9 KC	S-60009	±7½%	¾ x ¾ x 1⅜ H	1¼ oz.
10	5.4 KC	S-60010	±7½%	¾ x ¾ x 1⅜ H	1¼ oz.
11	7.35 KC	S-60011	±7½%	¾ x ¾ x 1⅜ H	1¼ oz.
12	10.5 KC	S-60012	±7½%	¾ x ¾ x 1⅜ H	1¼ oz.
13	14.5 KC	S-60013	±7½%	¾ x ¾ x 1⅜ H	1¼ oz.
14	22 KC	S-60014	±7½%	¾ x ¾ x 1⅜ H	1¼ oz.
15	30 KC	S-60015	±7½%	¾ x ¾ x 1⅜ H	1¼ oz.
16	40 KC	S-60016	±7½%	¾ x ¾ x 1⅜ H	1¼ oz.
17	52.5 KC	S-60017	±7½%	¾ x ¾ x 1⅜ H	1¼ oz.
18	70 KC	S-60018	±7½%	¾ x ¾ x 1⅜ H	1¼ oz.
A	22 KC	S-60019	±15%	¾ x ¾ x 1⅜ H	1¼ oz.
B	30 KC	S-60020	±15%	¾ x ¾ x 1⅜ H	1¼ oz.
C	40 KC	S-60021	±15%	¾ x ¾ x 1⅜ H	1¼ oz.
D	52.5 KC	S-60022	±15%	¾ x ¾ x 1⅜ H	1¼ oz.
E	70 KC	S-60023	±15%	¾ x ¾ x 1⅜ H	1¼ oz.

Designed and tested to specification #MIL-T 26985

Supplied in two principal case sizes:
1. For RDB channels 1 through 6, case size is ¾ x 1½ x 2¼ inches high; weight: 4 ounces.
2. For channels 7 and up, case size is ¾ inches square and 1⅜ inches high; weight: 1¼ ounces.

These cases are generally equipped with a 4-pin plug to match the small Winchester socket.

ATTENUATION CHARACTERISTICS
Impedance: 100 K ohms in and out.
Insertion loss: less than 6 db.
At ± 7.5% band width is less than 3 db.
At ± 25% band width is greater than 15 db.
At 1.75 f attenuation is 40 db or more.
At .57 f attenuation is 40 db or more.



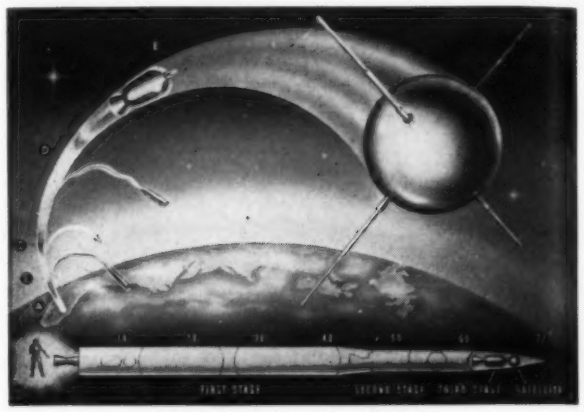
Burnell & Co., Inc.

Dept. MA47 45 WARBURTON AVENUE • YONKERS 2, N. Y. • YONKERS 5-6800
PACIFIC DIVISION • 720 MISSION STREET • SOUTH PASADENA, CALIFORNIA • RYAN 1-2341

For more information circle **11** on inquiry card.

News—*continued*

The timing device must withstand shock and high-temperatures associated with missile flights. Located in the 2nd stage of the 3-stage rocket, it will "program" the various functions until the 3rd stage is launched. Responsibilities range from orientating Vanguard in its precise path of flight to telemetering to ground



Timed Activation Points

instruments. Illustration traces rocket to orbit. At A, 72-foot long launching vehicle streaks upwards from launching site at Patrick Air Force Base, Florida. First stage achieves speed of about 3500 mph. B shows first stage burnout. Nose and vehicle drop back to earth. At C, second stage activities. Vehicle will blast to the 300-mile orbit with speed about 11,000 mph. Program timer will help aim vehicle like a rifle to give exact direction to the third-stage mechanism. At D, third stage steps speed of satellite up to approximately 18,000 mph. At E, man-made satellite is rocketed out of third stage vehicle. Microsecond accuracy in timing these sequences is essential to long life span in orbit. Designers for Industry, Inc., has been awarded the timer contract assignment.

For more information circle **106** on inquiry card.

Development Sub-contracts

PHILADELPHIA, PA.—George F. Metcalf, general manager of GE's Missile and Ordance Systems Dept., says an increasing area of profit for small business lies in the large amount of research and development sub-contract work now available in recent research and development contracts placed with his department and other prime contractors.

This Department, actively engaged in research, development, and production work for the Department of Defense, and a prime contributor to the Air Force's intercontinental ballistic missile program, recently announced receipt of a large arming and fuzing contract from the Ordance Corps. Subcontractors receive about 40% of the dollar value of the company's research and development contracts.

The advantage in this method of operation is that prime contractor can concentrate on systems engineering. In their specialized fields, sub-contractors often can do a highly skilled job on shorter schedules and less money than the prime contractor.

For more information circle **107** on inquiry card.

CR Tube Development

SAN DIEGO, CALIF.—Stromberg-Carlson, a division of General Dynamics Corp., announces establishment of a developmental cathode ray tube facility in San Diego, said to be the first facility on the West Coast for large cathode ray tube developmental work.

The materials laboratory and model shop, equipped to turn out a variety of experimental and developmental tubes, are housed at the Stromberg-Carlson tube plant in San Diego, where the company's CHARACTRON shaped beam tube is manufactured.

Work includes research with deflection yokes which will yield a more uniform field. One method under study is creation of a cross field through use of a diagonal winding—a trick mastered with the aid of a specially-designed coil form used in connection with an ordinary universal coil-winding machine.

One new project will be design of a tube to provide a picture from radar much more detailed than is achieved by present tubes. Other refinements include: 1. Improved quality of phosphorescent screens with special fine-grain phosphors. 2. More uniform electron beam through improvements in quality of the electron emitting material. 3. Designing cathode ray tubes mated with photographic devices in color of light, light output and lens design for better detail in photo-recording. 4. Use of optical quality face plates for improved transmission of the display.

For more information circle **108** on inquiry card.

Doppler Navigation Components

PLEASANTVILLE, N. Y.—Air Material Command, Wright-Patterson Air Force Base, Ohio, has awarded two contracts totaling over $4,000,000 to General Precision Laboratory Inc., Pleasantville, N. Y. a subsidiary of General Precision Equipment Corp., for manufacture of electronic control amplifiers and research and development work on advanced airborne navigation systems. The new production contract for control amplifiers is the second received by the company for the units, a component of GPL's AN/APN-89 Doppler navigation system.

For more information circle **109** on inquiry card.

DuMont Miniaturized Radar Tubes

Du Mont compact, high-resolution radar tubes save space and weight, and permit full use of miniaturization techniques in airborne and other portable radar receivers.

Available in 3" to 12" screen sizes. Magnetic or electrostatic focus and deflection. Nine-pin miniature base.

DU MONT®

Industrial Tube Sales, ALLEN B. DU MONT LABORATORIES, INC., 2 Main Ave., Passaic, N. J.

For more information circle **12** on inquiry card.

High-Temperature Seals

CLEVELAND, OHIO.—New contract from Wright Air Development Center calls for development of high-temperature materials for rotating seals in jet aircraft engines. Designs of Mach-2 and Mach-3 aircraft make it imperative that rotating parts such as bearings, gears, etc. be developed for operation at temperatures up to 1000°F. Work will be performed by Horizons, Inc., Department of Metallurgy.

For more information circle **110** on inquiry card.

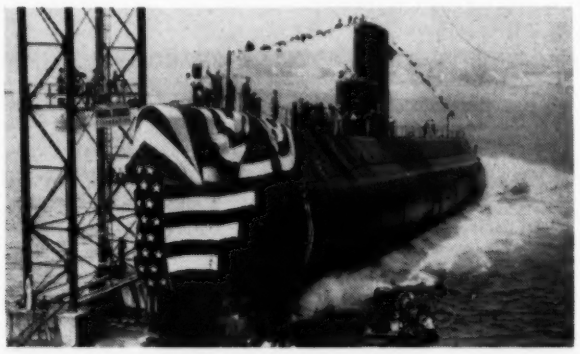
Rate Gyro

NEW YORK. N. Y.—Under new agreement, Sanders Associates will become a completely self-contained source of supply for its precise subminature rate gyroscope and related instruments. United States Time Corp., previously operating under license from Sanders, now has established its own research laboratories in Irvington-on-the-Hudson and plans research and development of the gyro and related instruments, as well as step up its volume production of the unit in view of the increasing demand by missile and airframe manufacturers. The unit will henceforth be marketed by Sanders as "Sanders Rate Gyro" and by U. S. Time as "U. S. Time Rate Gyro." Each of the producers will maintain a sales engineering force in the field to accommodate missile and airframe manufacturers, and each will receive inquires concerning the unit.

For more information circle **111** on inquiry card.

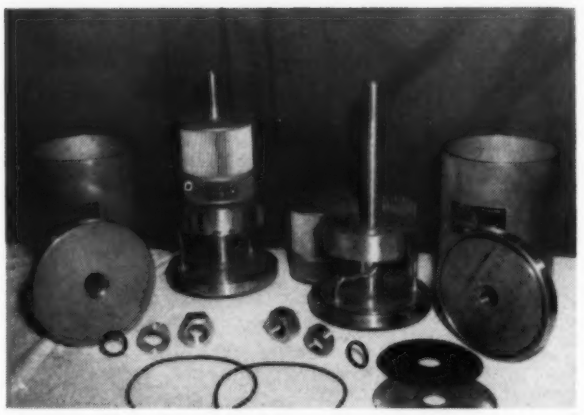
Underwater Air

PITTSBURGH, PA.—Even atomic submarines use many pneumatic control devices, and this necessitates a source of clean, dry "instrument-quality"



SEAWOLF Launching

air. The atomic submarine SEAWOLF has been supplied with a special Condensifilter unit that filters the air and condenses out water vapor introduced into the pneumatic control system, thus assuring proper function of these pneumatic controls.



Two Condensifilters Disassembled

The two units shown dismantled to reveal structure are built by Hankison Corp. to meet SEAWOLF's requirements.

For more information circle **112** on inquiry card.

News Bits

► The men "behind the scenes" responsible for DuMont's "400 series" shared the spotlight with the company's new instrument line at the national sales conference held March 14, 1957 in the Crystal Ballroom of the Hotel Delmonico, N. Y. C.

► General Electric Co.'s Technical Products Dept. announces receipt of a contract from U. S. Army's Signal Supply Agency, Philadelphia, Pa., for a closed-circuit color television system for closeup viewing of missile launching and tracking high-speed missiles to a possible altitude of 100,000 feet. System will be used at the Missile Test Center at Cape Canaveral, Florida.

For more information circle **113** on inquiry card.

Air-launched Sparrows

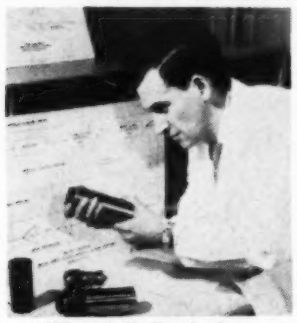
► Navy's new guided missile, Raytheon Sparrow III, is shown mounted under wing of Navy fighter. This new air-launched missile is intended for extensive use by Navy fighter aircraft in fleet air defense. The missile was developed by Raytheon Mfg. Co., which also is prime contractor for the Army's ground-to-air Hawk.

► New research and engineering group for study and improvement of high-power microwave switching devices is announced by Microwave Associates, Inc., Burlington Mass.

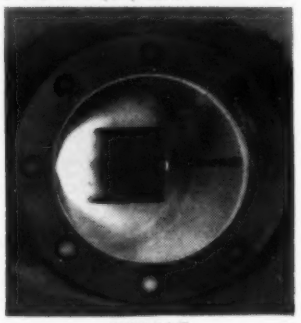
For more information circle **114** on inquiry card.

► High-precision missile devices, instrumental in harnessing the tremendous energy released by the new "exotic" fuels, will be developed and produced by Sperry Gyroscope Company's Air Armament Div. Currently used as guided-missile propellants, such solid and liquid fuels hold great promise for tiny, self-driven, precision instruments.

For more information circle **115** on inquiry card.



"Exotic" Fuel Gas Generator



9000°F

► Air and model glow instantaneously (in ten thousandths of a second) as airflow of 10,000 mph strikes blunt-nose model during hypersonic testing in the "wave superheater" at Cornell Aeronautical Lab. Temperature at the model's nose reaches about 9000°F, approximately the surface temperature of the sun. This new development, sponsored by the Air Research and Development Command's (ARDC's) Air Force Office of Scientific Research, will enable scientists to make laboratory studies of the effects on aircraft and missiles at such speeds for longer periods of time (15 seconds or greater) than ever before possible. High temperature and aerodynamic conditions acting on a ballistic missile re-entering the earth's atmosphere will be simulated by this facility.

► A jet utility trainer-transport, prototype under construction by Lockheed Aircraft Corp., will provide the military services with a multi-purpose vehicle having special capabilities in high-speed personnel and express transport as well as multi-jet-engine combat readiness training and crew training.

► Induction Motors Corp. announces its entrance into precision rotating components by establishing a West Coast Rotating Components Division within its recently acquired subsidiary, PSP Engineering Company, of South Gate, California.

For more information circle **116** on inquiry card.

► George L. Nankervis Co. announces it has been awarded a study contract by the Ford Motor Company to determine preparedness of the U. S. Naval Reserve Gas Turbine Facility in Romulus, Michigan. The plant was built in 1952 by Ford and was "moth-balled" the following year as a standby facility. The Nankervis Co. was the original contractor for the test cell instrumentation.

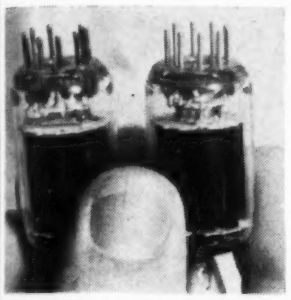
► Air Force Missile Test Center's tracking stations on the 5,000-mile Florida Missile Test Range will now be able to receive 1890 separate items of information from any missile tested on the range. This is made possible by new precision magnetic tape telemetry recorder developed for Air Research and Development

Command by Consolidated Electrodynamics Corp., in only 90 days.

For more information circle **117** on inquiry card.

► To assure good tube pin-to-socket contact in equipment using high-reliability miniatures, General Electric has developed a scouring process which turns out "Five-Star" tubes with brightly-polished pins (at right in photo). Oxidation residue formed on the nickel pins as a result of the 1000°C heat of the button stem sealing process is now cleaned with an abrasive emulsion.

For more information circle **118** on inquiry card.



Dirty pins—left

Polished pins—right

Hercules propjet

► Flight testing of the world's largest ski-equipped airplane, Lockheed's C-130 Hercules propjet, is observed by television camera under right outer wing of the "Ski-130," 62-ton Air Force combat transport. TV camera, equipped with wide-angle lens, is suspended in two-foot diameter fiberglass pod under the wing. Focus is fixed on the 19½-foot main skis and smaller nose skis, which are painted with candy-cane stripes for better visibility. The six-mile-a-minute propjet, fastest operational transport in the Air Force, is equipped with both wheels and skis and can take off and land on grass strips, snow, ice, or paved runways.

In tests just concluded by Brig. Gen. Thomas L. Bryson, Commander of Wright Air Development Center, the C-130 took off from icy, snow-covered Minnesota lakes at a gross weight of 111,000 pounds to set a new weight-lifting record for ski-equipped, 4 engine aircraft.

► Simplex Equipment Corp., of Bloomfield, N. J., formerly a GPE subsidiary, has been made a subsidiary of General Precision Laboratory, also a GPE subsidiary. A large portion of Simplex's 160,000 square feet of manufacturing space will be used to handle current and future orders for airborne Doppler navigation equipment.

For more information circle **119** on inquiry card.

► An Air Force officer has reached an altitude of 198,770 feet, nearly 38 miles, in an aero-medical altitude chamber test. It is the highest simulated altitude ever reached by man. Earlier Major Beck had attempted to reach 200,000 feet, but each time the Major exhaled, his breath counteracted the near vacuum at full power. For this latest test, a hose was run from his helmet's exhaust valve into an adjoining chamber. With this arrangement the chamber's mercury gage was brought down to 0.250 millimeters, only 0.0048 psi, before evaporation of his perspiration halted the chamber's ascent.

NONLINEAR CONTROL discussed by *Charles Taylor*

It may seem to be inconceivable that nonlinear control can be applied to complex dynamic processes. Excellent examples of such processes are to be found in the petrochemical industry. Paradoxically, however, nonlinear control is implied if optimum control of such processes is desired. Optimum is defined here in the sense that maximum efficiency, or economy, of plant operation be achieved for specified product quality in the face of changing plant conditions.

Even the word nonlinear has a bewildering connotation. If a system is nonlinear it is frequently assumed that the system transcends human understanding or control. To actually apply nonlinear control to a process (linear or nonlinear) seems further out of the question. A basic reason for this awesome stature is the fact that the familiar tools of linear systems design and analysis no longer apply. The principle of superposition (i. e., the sum of effects being simply related to the sum of causes) is not valid in the nonlinear realm. The mathematical foundations upon which engineering practice may be based are weakened without the generality afforded by the principle of superposition.

To understand why nonlinear control is implied in optimizing processes, it is necessary to appreciate the fact that a linear control system is, by definition, non-adaptive. Once the control parameters have been chosen in a linear system they are fixed (until manually changed). These control parameters may be visualized as weighting coefficients ascribed to the past, present, and future states of the system. The overall dynamic system behavior is determined by summing up these weighted past, present, and possible future system states regardless of the type of inputs or disturbances. In simple single loop-control systems this selection of the control parameters or weighting coefficients of past, present, and future behavior corresponds respectively to choosing the amount of integral, proportional, and derivative control action. This means that, at best, a linear control system must always be a compromise. If the past is heavily weighted, the system will tend to be sluggish. If the present and possible future states of the system are weighted more heavily than the past, the system may be capable of adjusting to sudden changes, or correcting for major disturbances, but there is the danger of erratic, unstable behavior. In practice "middle-of-the-road," or compromise, control parameter values must be chosen.

On the other hand, one form of an adaptive control system will have an ensemble of sets of control parameters from which to choose. The particular set chosen at any instant will depend upon the state of the process variables. The system will continuously switch from one set of parameters to another in order to satisfy an optimizing criterion in terms of maximum efficiency or economy as mentioned above. This type of control system will "learn from experience" and adapt to many different situations. By definition, adaptive control is of necessity nonlinear control.

Dr. Charles F. Taylor discusses nonlinear adaptive control for optimizing processes.

A useful by-product derived from this nonlinear control concept is that system performance becomes nearly independent of process conditions, such as weakening of catalyst activity in a petroleum process. An advantage of nonlinear adaptive control is that a detailed analytical description of the process is not required in order to achieve optimum performance. This benefit is of particular importance in petroleum processing where it is exceedingly difficult to obtain valid transfer functions or analytical models of the processes.

Fortunately, with the advent of reliable digital computers that can be "married" to complex processes, the future for nonlinear adaptive control is bright. Digital techniques are well suited to this method of control since the ensemble of sets of control parameters are finite and discrete. Further, sampling (in time) techniques may be employed.

Enter nonlinear adaptive sampled-data control systems!

By applying the latest proven techniques, our well-qualified staff at Daystrom Systems is prepared to take single responsibility of assembling and installing a system to meet your needs. We are currently compiling a file of new applications and papers on various parts of systems, both industrial and military. If you are interested in receiving the file and periodic additions, please write us.

DAYSTROM SYSTEMS

Division of Daystrom, Inc., 5640 La Jolla Blvd., La Jolla, California, Tel. GLencourt 4-0421

For more information circle **13** on inquiry card.

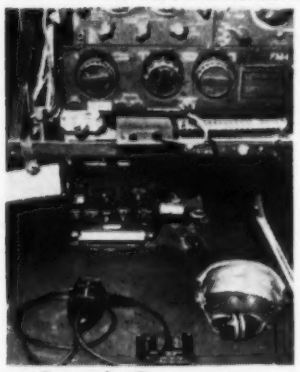
News—*continued*

► Herbert A. Finke has been advanced to general manager of Polytechnic Research & Development Co., Inc. He is responsible for all phases of operation of the company, which designs and manufactures microwave and electronic test equipment and components for the military and industry.

For more information circle **120** on inquiry card.

► Military needs for more intelligibility and a 50 percent longer range with field communications equipment now available prompted development of the speech compressor that squeezes peak values of voice sounds to nearly the same level as average sounds. Since intelligibility is more important than quality of speech, the narrow, almost monotone range of speech compressed to a 24-decibel limit serves the needs of communciation. Interference from background noises such as aircraft is lessened by the speech compressor and tests of ground-to-air equipment have shown that maximum range can be increased 100 per cent by use of the compressor developed by Temco Aircraft Corp.

For more information circle **121** on inquiry card.

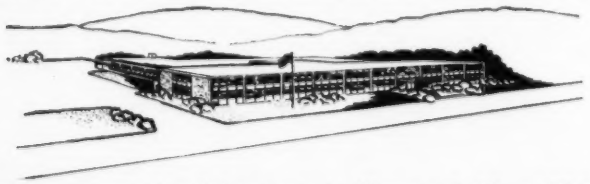


Speech Compressor

Lowering Reactor Vessel

► Construction of the Army Package Power Reactor, one of the nation's first atomic generating plants, nears completion as workmen lower the 31,600 lb. reactor vessel into the vapor container. This critical operation required lifting the specially-constructed vessel more than 60 feet and lowering it through an opening with less than one inch clearance. The APPR is a 2,000-kw pressurized-water nuclear generating plant being built at Fort Belvoir, Va., for the Army and Atomic Energy Commission by ALCO Products, Inc.

► The Control Engineering Unit of Detroit Controls Corp., Div. of American-Standard, has started erection



of an engineering laboratory in Norwood, Mass. This new million-dollar structure, scheduled for completion in April of this year, will be devoted entirely to engineering research and development of gyros, gyro flight stabilizers, and navigation and stabilization systems.

For more information circle **122** on inquiry card.

ARMED FORCES COMMUNICATIONS and ELECTRONICS ASSOCIATION CONVENTION and EXHIBIT

Sheraton-Park Hotel, Washington 8, D.C.— May 20-22, 1957

WE INVITE all AFCEA members and conventioneers to visit the *MILITARY AUTOMATION* exhibit, in booth 115. As an extra service for our readers, our May-June issue of MA will report on outstanding developments revealed during the AFCEA convention. At the time we go to press, the following exhibitors are listed:

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Alfax Paper & Engineering Co.	69
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TRENDS

Ratio of US Defense spending between missiles and aircraft in 1954 was 10 to 90; in 1955, 35 to 65; in 1956, 50 to 50.

Seat ejection techniques are increasingly successful in saving the lives of jet pilots, says the Air Force. While 77% of all recorded ejections to date have been successful, 90% saved the pilot's life in 1956.

Supersonic jets and missiles used 52% more stainless steel in 1956 than in 1955, due largely to a higher percentage of this material in high-speed aircraft.

Director of the Bureau of the Budget, Percival F. Brundage, has stated that in the 1957 budget $36 billion will be for the Armed Forces, which is $300 million more than actually spent in '56, which in turn was $150 million more than was spent in '55.

Power transistors amounted to 15% of all types of transistors in 1956, with about 1.9 million units produced. The same ratio is expected to hold in 1957 with a total production of over 4.5 million power transistors.

Sylvania has estimated that plant investments by the electronic industry through 1956 were $9.2 billion—will reach $11.5 billion in 1960 and $15.4 billion by 1966.

Relay manufacture in 1955 produced 14.3 million units worth $84.8 million. In 1956, 17.2 million units worth $113.7 million were produced. The National Association of Relay Manufacturers predicts 20 million units worth $142 million in 1957. Designs for increasingly difficult environmental conditions required by military applications are credited with the rise in unit costs.

According to FORTUNE Magazine, missile system expenditures amounted to $1.2 billion in fiscal 1956. It is anticipated that over $2 billion will be required for the electronics portion of the missile program when big missiles are brought into production in fiscal 1958.

Government apparently spent $340 million for advanced research and development for electronics in 1956, compared to $72 million in 1951. Industry, it is estimated, spent $600 million in 1956 for research and development.

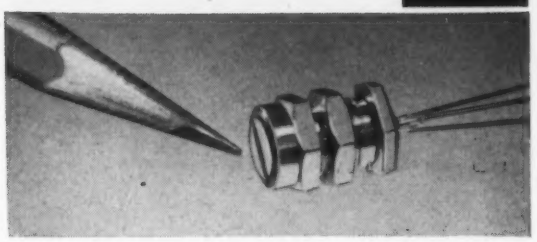
Fewer than 100 out of about 4,000 companies in electronic manufacturing make nearly 75% of its products.

Competition in all electronic markets has increased greatly in the last two years. The result: profit margins before taxes dropped from a high of 15% of sales in 1950 to less than 8% in 1955.

THE MILITARY ELECTRONIC MARKET (in millions)

	1947	1950	1956
Aircraft Equipment	$45	$150	$1,015
Missiles	00	10	640
Other	30	240	1,335
Total	$75	$400	$2,990

TYPE 101C LOCKING BUSHING POTENTIOMETER



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Component-Test Automation

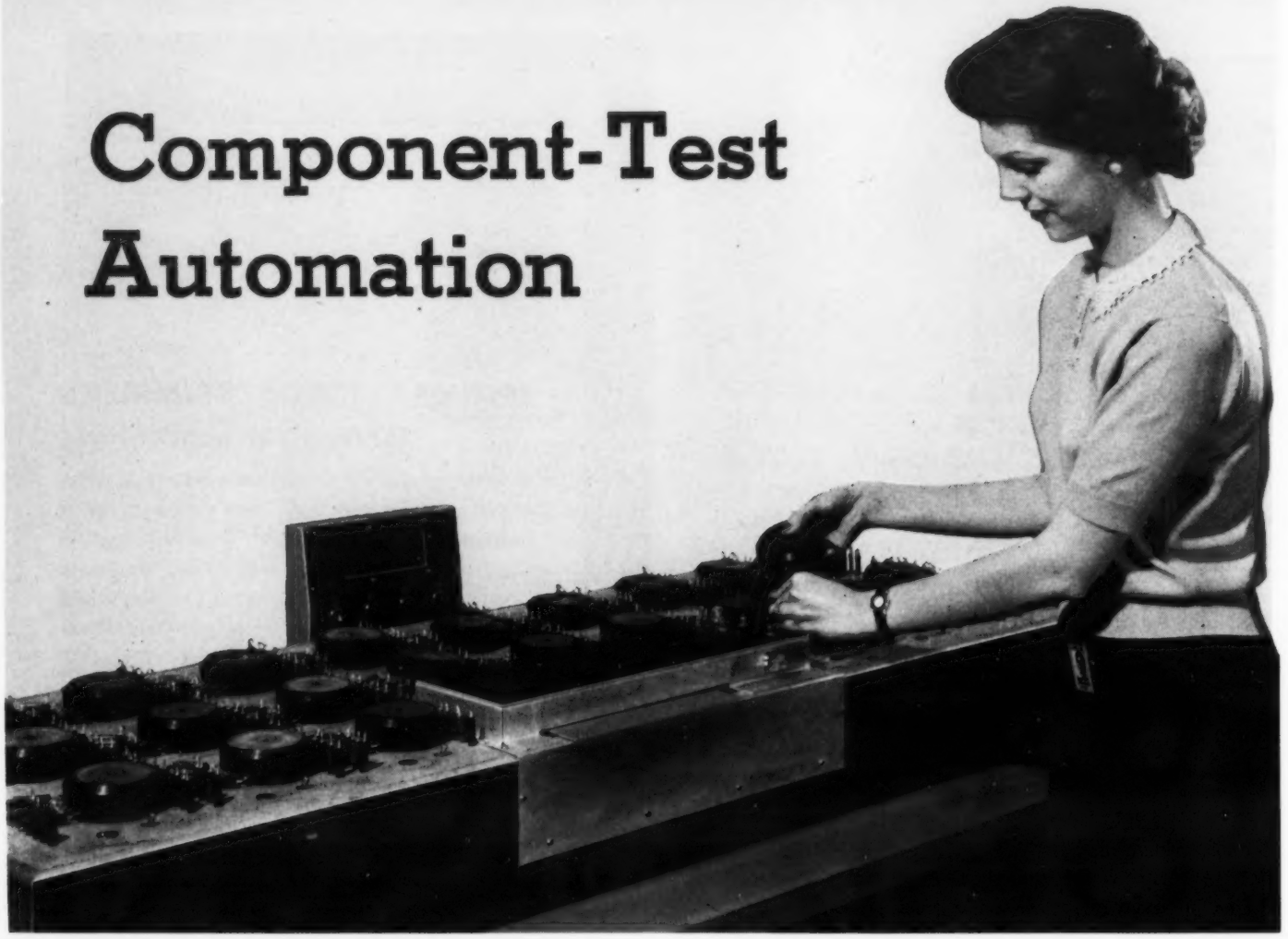


FIG. 1. AUTOMATIC TURNS-RATIO TESTER determines ratio of turns between primary and secondary transformer windings. The ratio appears as a three-digit number to the operator. Transformers with as many as five windings can be tested in 15 minutes. Test time saved—90%.

Automatic testing of military equipment components results in savings in test time: 50% for fire control computers, 95% for molded unit assemblies, 90% for multifunction tests on airborne power units, 90% for precision-ganged potentiometers, 90% for cable harness checks, and 90% for turns-ratio and d-c resistance checks on transformers. A higher quality of output and greater reliability of products are also achieved, using relatively unskilled labor.

COMPONENT manufacture for military use has been characterized as basically a small-job operation, in contrast with the large-job runs for commercial production of electronic items. High obsolesence rates and frequent changes in specifications to meet urgent military requirements make flexibility a prime consideration of any components assembly or test line setup for military production.

This fact, together with the inherent fragility of most electronic assemblies, has delayed the application of automation to the assembly and testing of electronic components for military use. However, the trend is now turning in the direction of automation, since higher quality output, greater reliability of product, and production economies are made possible even with relatively unskilled labor.

Automation Logistically Important

Automatization in military electronic manufacturing is of interest not only to industry but is an extremely important factor in military logistics. The production capacity that such machines can provide in an emergency is equivalent in some degree to a stockpile of equipments, as production lead-time can be greatly shortened if labor recruitment and lengthy training programs are not required for expanded production. Automatic service testing of military electronic systems in ships, by Air Force maintenance crews and by Army Field forces may also develop from such small beginnings, if system designers provide in advance for the requirements of automatic testing.

The Westinghouse Air Arm Division, Baltimore, Md., occupies 330,000 square feet, and employs 1550 persons at the production line in the manufacturing and assembling of five categories of military equipment: fixed and flexible armament control systems, missile control systems, automatic flight control systems and aircraft defense systems. Each system contains 25 to 30 assemblies, with as many as 11,000 electrical and mechanical parts.

Test hours formerly required 30% of the total hours required to produce a system.

Automatic test equipment now in use falls into three basic classes:

(1) Equipment designed for basic type of test that can cover a wide range of parts and tolerances;
(2) Equipment designed for a number of general tests; and
(3) Equipment designed for a specific application and not usable elsewhere.

Turns-Ratio Test

The Automatic Turns-Ratio Test Set (Fig. 1) which accommodates 24 transformers with up to five windings each, is an example of the first class of test set. The machine is a card-controlled, automatic turns-ratio bridge, displaying a digital read out. The machine will step ahead after each test provided the turns-ratio falls within limits programmed into the punched cards. If the turns ratio is incorrect, the machine will stop, indicating the actual turns-ratio measurement on the digital display. One indicator lamp shows the operator the transformer that failed, and another lamp shows which winding of that transformer failed.

The only requirement for testing different types of transformers is the changing of punched cards.

D-C Resistance Check

The Automatic DCR (Fig. 2) tests transformers for d-c resistance of the windings. The resistance range may be 0.001 ohm to 10,000 ohms. This type of automation design was adopted because of high-volume, one-type-test application. The system employs a d-c resistance bridge and a card-controlled programmer with digital read out. The test indicator shows all results, good or bad.

Cable Harness Check

The Automatic Cable Harness Checker (Fig. 3) is a continuity, short-circuit, and leakage tester capable of making up to six checks a second.

By an ingenious system of charts and lamps, the machine identifies the location of the trouble. For instance, if a short or open occurs, the machine will stop operating and the appropriate indicating lamp will inform the tester which circuit is at fault. A cardboard grid-chart, shown on the test machine, is marked by the operator, and the test proceeds. The chart is

then used as a guide for the repair of the cable harness.

The basic device is capable of testing 200 circuits. Multipliers can be added to increase the number of tests to 400, 800 or 1200. This machine is capable of testing multiple circuits with as many as 56 common circuits without multipliers.

The unit can be set to stop on continuity currents from 0.1 ampere to 2.0 amperes in five steps. It can be set to stop on leakage resistances from 200 meghoms to one megohm in seven ranges.

Potentiometer Tester

The Automatic Potentiometer Tester (Fig. 4) will position the shaft of a gang-operated precision computing potentiometer to a mechanical accuracy of ±2 minutes of arc and an electrical accuracy of ± 0.015 percent of full scale.

To perform these checks, the pot-testing machine is controlled by decks of punched cards. These cards set up the individual test, indicate the accuracy limit desired, and control the machine making the test. The potentiometers are tested for resistance, linearity of conformity, dielectric strength and electrical noise. One test operation is made each second. Formerly, pot test for a six-cup gang took about four hours; with this device, only 10 minutes are needed and much greater accuracy is achieved.

Multi-Function Tester

The Automatic Function Tester (Fig. 5) makes continuity, leakage, resistance, impedance, a-c voltage, and d-c voltage measurements at a rate of three tests per second. An adapter which plugs into the top of the Calif. Technical Ind. Supertester contains selector switches which program the testing sequence, select standards on each test, and direct the bridge and range-selecting circuits in the machine. The bridge circuits are designed so that all standards are resistors.

The machine measures leakage resistances from 100 to 500 megohms to an accuracy of ±10%. Continuity resistance can be measured between 0.1 and 5 ohms to an accuracy of ±0.05 ohm. D-c resistance can be measured from 1 to 10 megohms to an accuracy of ±1%. A-c measurements can be made in the frequency range of 50 cps to 20 kc with an accuracy of 1%.

FIG. 2. AUTOMATIC DCR measures d-c resistance of transformer windings. After starting, no operator is required until all tests are completed. Test time saved—90%.

FIG. 3. AUTOMATIC CABLE HARNESS CHECKER is used chiefly for circuit checking of chassis and cable harness. Test time saved—90%.

FIG. 4. PRECISION POTENTIOMETER CHECKER measures ganged potentiometer resistance, function conformity, dielectric strength, and noise, automatically. The machine cycles one test per second via punched cards. Test time saved—90%.

FIG. 5. AUTOMATIC MULTI-FUNCTION TESTER measures impedance or voltage of components in electrical circuits and does functional tests. Tests are automatically programmed at rate of three per second. Test time saved—90%.

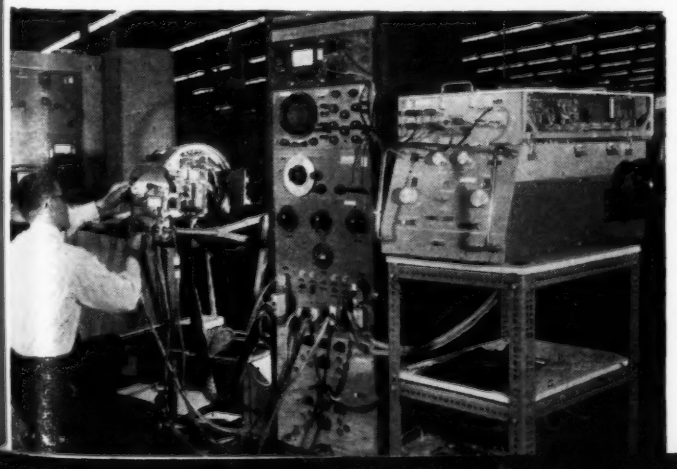
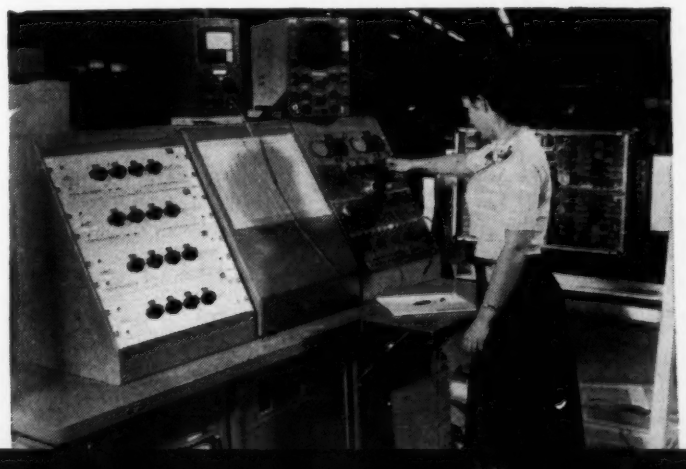


FIG. 6. AUTOMATIC MOLDED UNIT TEST SET checks packaged oscillators, amplifiers, modulators, etc., while their circuits are energized. The machine automatically programs as many as 14 tests to each unit at rate of one test per second. Test time saved—95%.

FIG. 7. COMPUTER TEST STAND provides semi-automatic testing of fire-control analog computers. Forty-eight test problems involving 13 input parameters can be solved. Time saving during alignment is 2 to 1, during operation 8 to 1.



One unusual feature of this test equipment is the self-testing adapter which checks its own components. This tester can be adapted to different equipments by using a differently wired adapter for each model.

Molded-Unit Tests

The Automatic Molded Unit Test Set (Fig. 6) provides rapid, accurate operation for both static and dynamic testing of small molded electronic circuits containing tubes, resistors, capacitors and transformers. The units tested vary from simple resistive networks to complicated amplifiers, inverters, modulators, demodulators, etc.

The change in setup required for each different type of unit is made in ten seconds by means of a prewired patchboard, which the operator is shown plugging into the machine. Other patchboards are shown in the racks above the test equipment. As long as the output of the unit under test is less than the standard, the meter will read negative and the pointer will hit the left limit switch. If it is greater, the meter will read positive, and the pointer will hit the right limit switch. If the proper information is fed into the sense relay, the machine will move to the next test automatically. Faulty units are tagged by the operator with a tag telling which part or parts are faulty. This device performs appropriate tests on each unit at a rate of a test per second. The total number of tests per units varies with test complexity. Units not under test are disconnected and can be removed safely and the sockets refilled while the test on another unit is proceeding. A test time reduction of 95 percent has been accomplished by the use of this automatic test machine.

Computer Test Stand

Semi-automatic Computer Test Stand (Fig. 7) is a special machine for the automatic test and manual alignment of airborne fire-control computers. This machine executes an over-all performance check representing operation during an actual mission by presenting a maximum of 624 bits of problem information to the computer, which must be solved to a high degree of accuracy. The speed of operation has increased by a factor of 8-to-1 during test problem operation and by a factor of 2-to-1 during alignment.

Over-All Results

The computer test stand has resulted in savings of over 50% of test time. Test time reduction of 95% was achieved by use of the molded-unit tester; savings of 90% of test time was achieved with the multi-function tester, the potentiometer tester, the cable-harness checker, the d-c resistance checker, and the turns-ratio tester. The increased reliability of tests is particularly important for components produced for maintenance parts, as these do not receive a functional test as a part of a complete equipment.

High-Temperature Tubes

JAMES E. BEGGS

Electron Physics Research Dept.
General Electric Research Lab.

TUBES constructed from titanium metal and special ceramic parts can operate at temperatures up to 800°C. They can be made so as to require no heater power for operation at 400°C and above. When these tubes use titanium grids and passive cathodes, they can be made to exhibit a built-in bias of up to two volts, so that no grid battery is required. They can have exceptionally high values of transconductance, have shown stable characteristics for many thousands of hours on test and, therefore, seem to be the forerunners of a reliable and unique class of tubes.

Materials with desirable high-vacuum characteristics are selected. Insulators are made especially free of contaminants harmful to cathode emission. Most other parts are made of titanium, a metal that will absorb gases rather than evolve them. Because the speed at which titanium can "getter" accelerates at elevated temperatures, vacuum and emission at high temperatures can be the same or better than at room temperature. Some of the special tubes the laboratory has made will operate at temperatures above 800°C (Fig. 1).

Cathodes for Heaterless Operation

Higher ambient temperatures mean less heater power is required for normal cathode operation. At 500°C, tubes require only half the heater power required at room temperature; at 700°C, appreciable emission can be obtained without any heater power. The amount of emission available depends on the cathode area; Fig. 2 shows 60 ma are emitted per square centimeter of cathode area at 600°C for these heaterless tubes. This means a cathode with an emitting surface of 0.25 sq cm will provide 15 ma current at 700°C without heater power. To get the same current without heater power at 600°C. The triode (Fig. 3) is an example of such a tube. Thus heaterless tubes can be designed for operation at specific elevated temperatures by using a cathode of sufficient area to provide the required emission.

Low Grid Emission

When the entire tube is operated at elevated temperatures, one might expect the grid to emit as readily as the cathode since it will become covered with material evaporated from the cathode. This does not happen if the grid surfaces are titanium metal. At temperatures of 400°C and above, titanium will react

Fig. 1. New vacuum tube, a laboratory model of the 6BY4 micro-miniature ceramic tube, operates while in flame of blowtorch. Oscilloscope pattern in background shows steady performance of the red-hot tube.

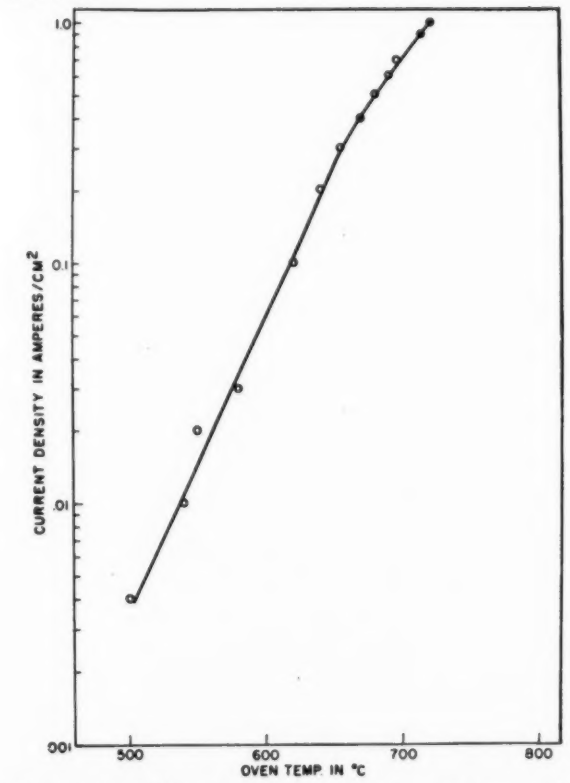


Fig. 2. Heaterless emission at various environmental temperatures.

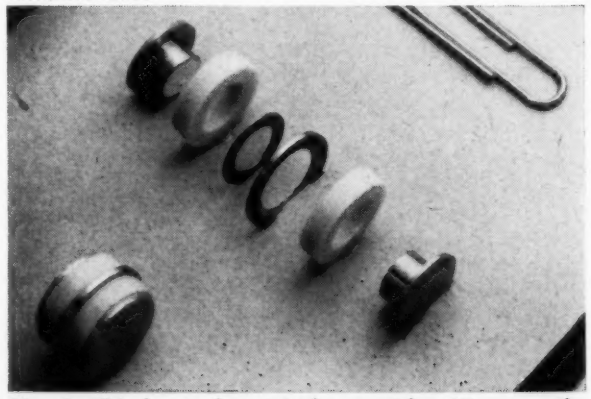


Fig. 3. This heaterless triode provides 15 ma cathode emission at 600°C.

with barium oxide that condenses on it, absorb the oxygen, and maintain a clean surface covered at most with a partial layer of barium. The amount of barium remaining on a titanium grid operating at the same temperature as the cathode depends on the type of materials and processing used for the cathode. Material is evaporated at such a slow rate from a passive cathode that the grid will be able to maintain an essentially clean surface and have a low level of emission. Once an equilibrium condition is reached, the emission from the grid can be a million times less than that from the cathode.

Contact Potential Between Grid and Cathode

A low level of grid emission means that the work function of the grid is higher than that of the cathode. This causes a positive contact potential between grid and cathode. If we assume a cathode work function of 1.6 ev, an initial velocity potential of 0.1 or 0.2 ev, and the work function of titanium as 4.1 ev, then we would expect a positive contact potential difference of about 2.4 ev to prevail for a clean titanium grid opposite an oxide cathode. Therefore, a titanium grid opposite a passive cathode is essentially clean because the contact potential difference is about 2.0 volts (a value that has been maintained for over 3000 hours at temperatures of 600°C). Thus, by operating at high temperatures, it is possible for the first time to achieve and maintain a positive contact potential between cathode and grid.

Built-in Grid Bias

A triode having a positive contact potential of 2 volts is extremely useful. Its characteristics are similar to those shown in Fig. 4. By having the zero grid bias curve in the middle of the plate family, the input signal can be applied directly between grid and cathode without need for a bias battery or resistor-capacitor network. Because current is negligible until the grid is more than 2 volts positive, input impedance is high. The circuit for a tube of this type is simple (Fig. 5). No heater or grid bias supply is needed. The tube is operated from a single battery with sufficient power to provide the required output. Thus, high-temperature circuits can be simpler than circuits for low-temperature tubes.

High Transconductance

Exceedingly high transconductance at low current has been attained in heaterless triodes. A G_m of 6000 at 1 ma has been achieved in a laboratory triode operating at 600°C. This high transconductance at such a low plate current is possible because a cathode of large area can be placed close to a finely detailed grid. This is possible in heaterless tubes because the grid frame operates at the same temperature as the grid wires so that the wires remain taut. In planar tubes of conventional design the grid wires above the cathode become hotter than the supporting frame. The wires sag unless the span is short, and when the cathode is heated it expands toward the grid making it

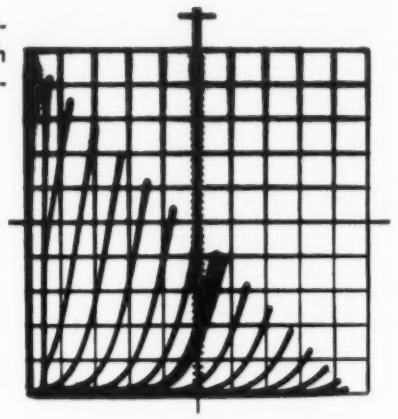


Fig. 4. Characteristics for triode with positive contact potential of 2 volts.

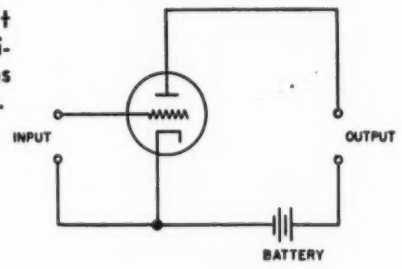


Fig. 5. Circuit simplified by elimination of grid bias and heater power.

more difficult to maintain desired spacing. In heaterless tubes the thermal expansion characteristics of the metal and ceramic parts are almost identical so that spacings remain essentially constant at all temperatures permitting design for higher transconductance per milliampere than has been practicable heretofore.

Photographs courtesy GE Research Lab., Schenectady.

For more information circle **201** on inquiry card.

Missile Scoring Pod

WHIT HILLYER

Bell & Howell Co.

A NEW missile-scoring camera "pod" determines how and why a guided missile hits or misses its aerial target (Fig. 1).

Since missiles and target both fly at velocities approaching the speed of sound and at altitudes far beyond the range of human vision, a remotely controlled system of recording data is a vital tool in evaluating missile accuracy.

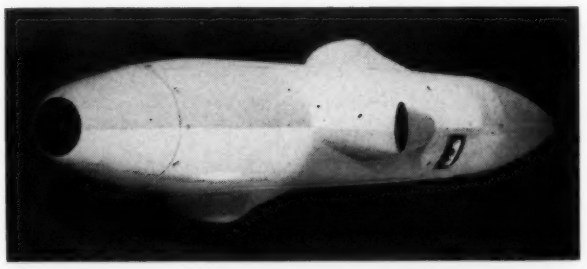


Fig. 1. Each pod contains four watertight, interchangeable cameras fitted with 142-degree wide-angle lenses. Operating speed is 200 frames per second, exposure time 1/600 second per frame. The high speed permits extreme slow-motion study of the projected film.

Cameras

Mounted on wing-tips of drone target, each missile-scoring pod contains four 16-mm high-speed Bell & Howell motion picture cameras. The eight cameras

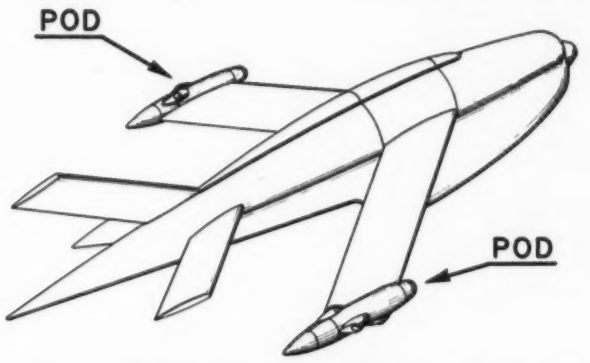


Fig. 2. Missile-scoring pods attach to wing-tips of drone target aircraft.

(four to a pod with one pod on each wing-tip) are so aimed that the approaching missile is always covered by no fewer than two cameras. 200-foot film capacity of each camera is sufficient to cover as many as four missile passes at the moving target with 10-second remotely-controlled motion picture "bursts." So long as the target is not shot down, four tests may be made on one roll of film.

Scoring

Scoring of missile behavior is done by assessing the film records against suitable grid coordinate charts. Data shows missile trajectory, miss-distances, and other functional characteristics. Built into each camera is an electronic timing device which indicates on film the time elapsed in fractions of a second for evaluating missile's path and speed. The system permits proper scoring of missile performance when drone is operated at velocities up to Mach 0.95 and at altitudes from 5000 to 50,000 feet. Built-in heating elements assure optimum camera performance at outside temperatures as low as —65°F.

If there is a direct hit, pods are jettisoned without damage by an explosive bolt, or "squib." Once free of the drone, the pods are lowered to earth by means of self-contained 16-foot parachutes. For recovery from water, they have non-mechanical flotation gear which keeps them surfaced for 24 hours, built-in dye markers and an exterior finish in standard government recovery colors.

Access doors permit reloading or replacing cameras without removing the pod from the wingtip.

Each pod weighs approximately 90 pounds ready for use, the separate drone-mounted electrical control gear weighs around 35 pounds.

Production quantities of the scoring pod now are being delivered to the Navy, and are available to companies working on missile-scoring or rocket-scoring systems.

For more information circle **202** on inquiry card.

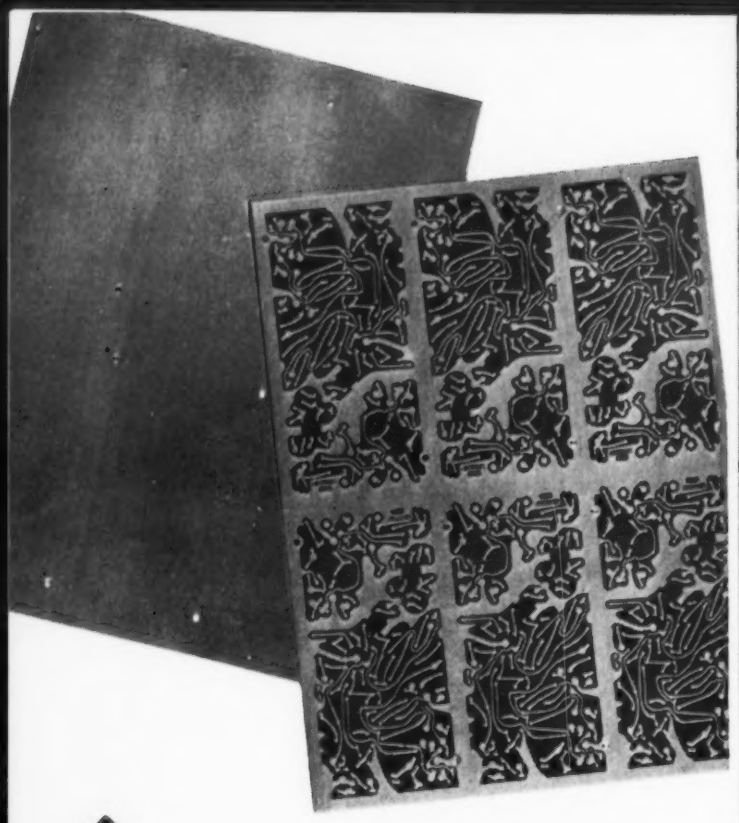


Fig. 2-1. Steps in the subtractive process. (Photo courtesy Croname Inc.)

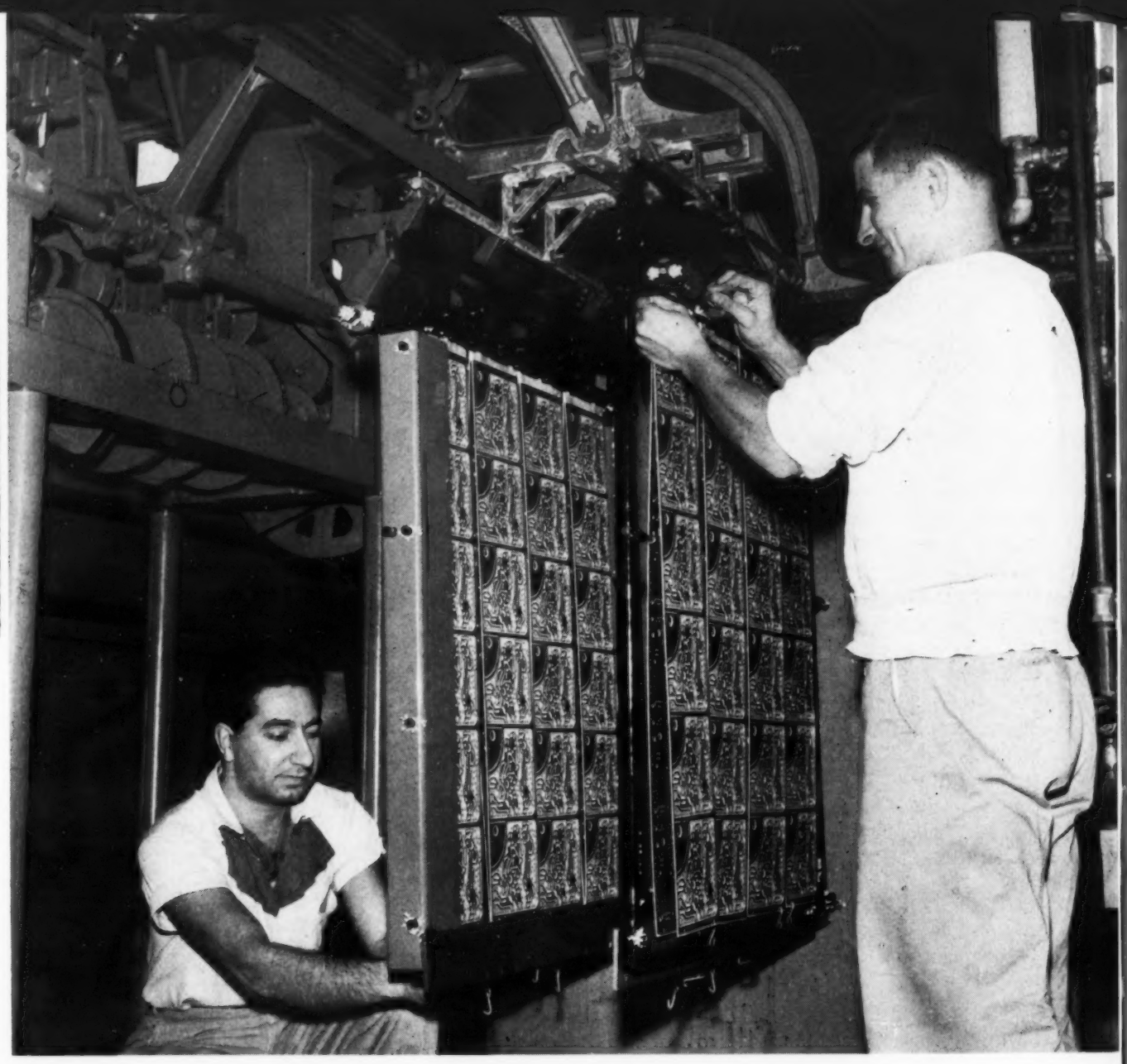
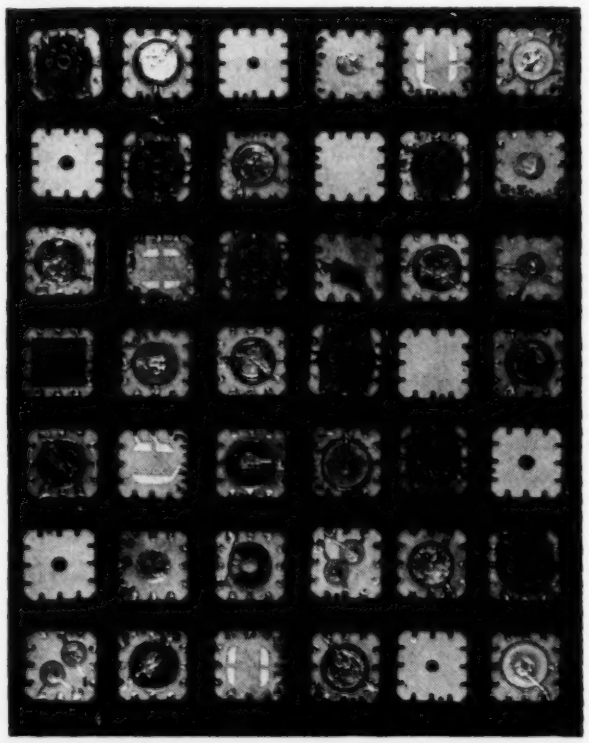


Fig. 2-2. Loading for plating step in making printed wiring by additive process. (Photo courtesy Specialty Electronic Components Dept., G. E.)

Fig. 2-3. Wafers for printed circuits from project Tinker Toy. (Photo courtesy National Bureau of Standards.)



Printed Circuitry

II Development

Following last issue's introduction to Printed Circuitry, this month we review its historical development and feature the most significant commercial techniques.

ALLAN LYTEL, General Electric Company

PRINTED CIRCUITRY has developed rapidly. J. A. Sargrove of England, one of the first contributors, used the fundamental principle of depositing conductors and other materials to form the wires and other components as early as 1937.

Etching, now a popular process, appeared in the open literature before World War II. At this time similar work was going forward in this country for the military. Both C. Brunetti and R. W. Curtiss were among the first to publish results of their work.

Subsequent progress has been rapid—now almost every electronics manufacturer has some printed circuits, in one form or another, in one or more of his products.

Among the more interesting developments relating to

the field is the TinkerToy method. Here the basic element is a small slab of ceramic material on which components are produced (Fig. 2-3). A stack of wafers, inter-connected by vertical wires, makes a completed circuit-module. The vertical wires are structural, not printed, making TinkerToy more a related approach to *modularization*—a subject which will be described later.

Two Approaches to Wiring

In the *additive* process, metal is added to the base to form the final wiring (Fig. 2-2). The name *additive* is derived from the method—adding metal to the base.

In the *subtractive* process, metal is removed from a base first coated with a thin layer of metal. When the undesired metal is removed, the final circuit remains. This is known as the subtractive method because metal is subtracted from the metal-clad base. An example of this process is shown in Fig. 2-1, which shows a typical board before and after removal of metal from the copper-clad base.

These two basic approaches lend themselves to many different manufacturing methods. The National Bureau of Standards has listed the following alternative methods of manufacture:

Resistors and conductors can be brush painted or sprayed through stencils or masks.

Capacitors can be built into the base-plate.

One can stencil capacitors and conductors at the same time when a high-dielectric-constant base material is used between conductors.

Conductors stenciled on a phenolic base can be cured at the same time the base is cured.

Conductors can be printed using silver "ink" and ordinary printing-press techniques.

Special resistor and conductor paints can be applied using special pens, brushes, pencils, or ordinary metal, rubber or plastic stamps.

Engraving techniques can be used to produce lines which are then filled with paint.

A stencil-coated base can be dipped into the proper paint.

Molten metal can be sprayed through a stencil, or sprayed on a premolded pattern, or poured into grooves made in the surface of the base material.

Chemical silvering and reducing solutions can be sprayed or poured onto a stencil-covered panel to deposit metal films of the desired circuit on the base.

Imprinting a catalyst onto the insulating panel can assure depositing copper in the desired circuit pattern.

Metal films can be evaporated in a vacuum to a stencil-covered base.

Cathode-sputtering in a vacuum can put a metal film on a base panel through a stencil.

Undesired metal can be removed by spraying abrasive material through a stencil.

Hydrocarbons, cracked at high temperatures, can produce resistors on a stencil-covered surface.

Circuit-wiring can be die-stamped from a metal plate and soldered or riveted to a panel, or fastened with adhesive.

Die-stamping metal foil onto a base-panel with a hot die imprints a metal pattern of the circuit on the surface.

Metal or carbon powder can be dusted onto a tacky surface through a stencil or captured electrostatically. The powder is then either fired or plated.

Decalcomanias with a metallic surface pattern can be applied to the base material.

Commercial Methods of Manufacture

Although many of the methods listed above have been used at one time or another, only about eight are now in active use. Other modifications may be found, but these eight seem to be the most important current methods—etching, painting, spraying, chemical deposition, vacuum processing, die stamping, dusting and molding.

Etching

First a base material is covered with a copper surface. A printing process can be used to transfer the negative of the desired circuit to the plated board using an acid-resist ink. Only the portions which are not printed with resist will be removed in etching. The remaining copper surfaces then form the final circuit.

Several methods used for etching are shown in Fig. 2-4. These methods are photoengraving, offset printing, silk-screening, and plating. In photoengraving (Fig. 2-4, part A), a light-sensitive layer* is added to the copper. The negative of the circuit is transferred to the photo-sensitive layer by photographic means and developed much as a photograph is developed. The sensitive layer which remains is the resist, so named because it resists the action of the etch bath that removes the undesired copper.

In offset printing, the desired circuit is printed on the copper-plated base material using normal offset printing techniques (Fig. 2-6). The ink is dusted with a powder which is fused in place. The unprotected copper is then removed by the etching bath.

Silk-screening techniques also can be used to place the desired circuit pattern on the copper-plated base. The remaining procedure follows that shown in part B of Fig. 2-4.

In plating (Fig. 2-4, part C), the *reverse* of the circuit pattern is printed on the copper-clad base by any of the aforementioned techniques. Then the board is plated with another metal, such as gold, silver, nickel, and rhodium so that there is a protective plating where the final wires are to be. The ink coating is removed and the board etched with ferric chloride. Lead-tin solder can be plated-on as a resist and chromic acid (Philip A. Hunt Co., Palisades, N. J., and others) used for etching. After etching, only the final copper-plated circuit remains.

Etching is also used while making plated holes as in Fig. 2-5. In applications where wiring is used on both sides of the board, the plating-through technique can be used to connect the wiring on one side with the wiring on the other side. Plated holes also are used as terminals for connecting components.

*Tuftop-Mallinckrodt Chemical Co., New York, N. Y.; also Eastman Photo-Sensitive Resist, Eastman Kodak Co., Rochester, N. Y.

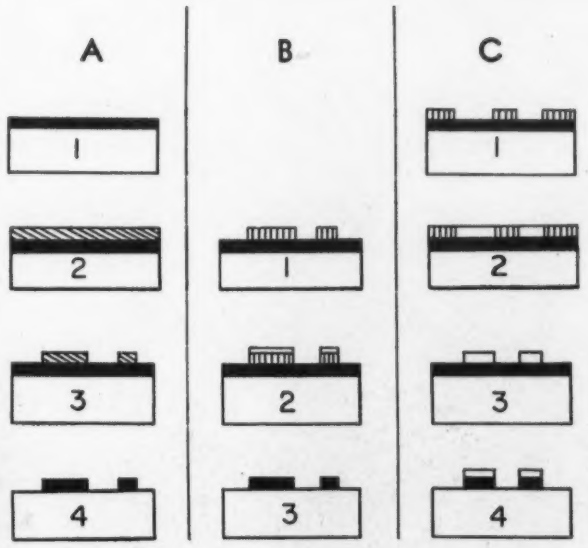


Fig. 2-4. Etching by various techniques. In photoengraving, column A, 1 shows board with copper coating, 2 shows light-sensitive coating placed on copper; 3 shows resist pattern after development of the exposed circuit pattern; 4 shows etched board with excess copper removed. Offset printing and silk screening follow procedure shown in column B; at 1, circuit is printed on copper; 2 shows powder dusted onto ink and fused to make resist pattern; at 3, etching removes unprotected copper. Column C shows plating; at 1, reverse of the circuit pattern is printed on the copper; at 2, copper is plated where final wires are to be; at 3, resist coating is removed; at 4, etching removes the undesired copper.

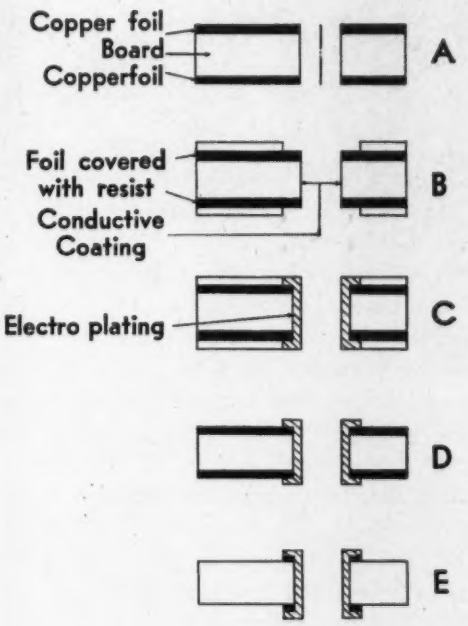


Fig. 2-5. Plated-through holes. At A a hole is made in the copper-plated board; at B, a negative of the desired pattern is printed with resist and the hole is coated with conductive material; at C, hole is electroplated—note flanges; at D, resist is removed; at E, etching removes undesired copper—note part of original copper foil under flange.

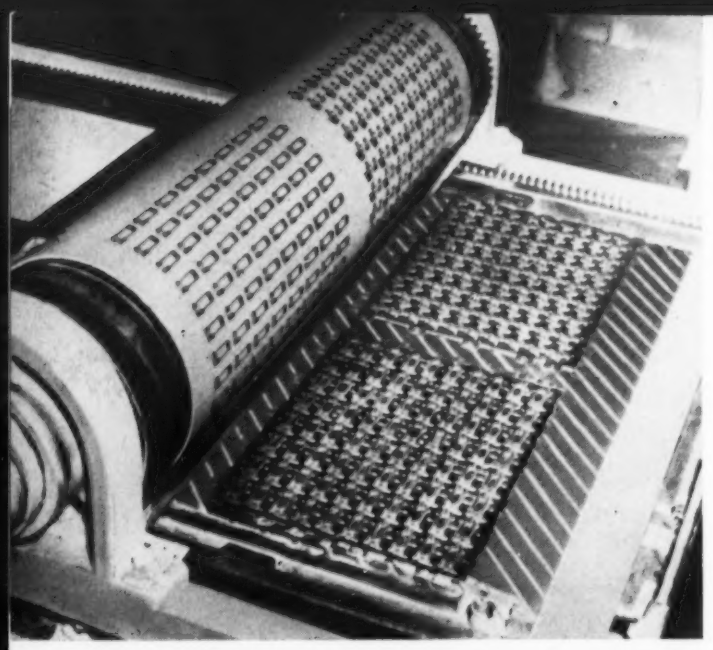


Fig. 2-6. Producing the circuit design on the copper-foil surface by offset printing.

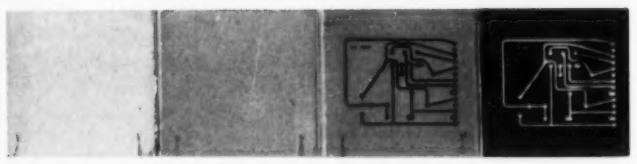


Fig. 2-7. Electrofax method of producing printed circuits starts with clean copper-coated board at A. At B, copper is coated with zinc-oxide sensitizer, surface is charged at 7 kv, and board is given 1/10-sec exposure. At C, board is dusted with toner powder and fused in oven. After the sensitizer is removed by a selective solvent, the board is etched from 2 to 6 minutes in ferric chloride and rinsed with water. D shows finished board. (Photo courtesy RCA.)

First, a hole is made in a board coated on both sides with copper. Then the negative of the desired pattern is applied in resist. A conductive coating is then applied wherever there is no resist—with particular attention to inner walls of the holes. Electroplating puts a copper coating on the areas with the conductive surface. When the resist is removed, an etching bath removes excess copper leaving a plated-through connection between the board surfaces. Thru-Con* is another plating-through technique.

A method called *Electrofax* has been used for experimental purposes by RCA. As shown in Fig. 2-7, the copper-coated board is coated with a zinc oxide sensitizer then electrically charged to 7 kv. After exposure of 1/10 sec. it is dusted with toner powder and fused in an oven. This fixes the image. After the sensitizer is removed with a selective solvent, the board is etched in Ferric Chloride and washed with water. This system (1) is dry, (2) allows projection printing, (3) has short exposure time, (4) shows results quickly, and (5) the boards have indefinite life and can be recharged, recoated and stored in light because they are not light sensitive until they are charged.

*Trade Mark—Specialty Electronics Component Dept., G. E.

Painting

It is possible to obtain paints for both conductors and resistors and apply the paints manually with a brush. This is not a production technique, but it can and is being used for single boards for experimentation.

A conventional printing press can be used for production of printed boards, using silver paint for ink. First the inked roller coats a positive master plate of the circuit pattern. Then the inked master is pressed against the base plate and the silver ink is deposited forming the wiring. If the lines are not thick enough, several impressions can be made.

Spraying

Molten metal or paint can be sprayed on the base material. When a stencil is used, the areas where the stencil is cut away allow the metal or paint to be passed through to the base. Both conductors and resistors may be sprayed.

In some cases, grooves placed in the base during the molding process make it possible to spray molten metal that collects in the grooves to produce wiring.

Two special sprays can be used at the same time. When they meet at the surface of the base, their interaction reduces a metallic silver which adheres to the base.

A subtractive spraying method begins with a thin metallic layer on the base plate. Then the pattern of the desired circuit is applied by a photographic process. Only the undesired portions of the metal are left exposed through the stencil-like pattern. A abrasive spray is passed over the board. The abrasive action removes the undesired metal and leaves the final circuit when the stencil coating is removed.

Chemical Deposition

This uses the same techniques used for silvering mirrors. A silvering solution is poured in the open areas of a stencil-covered base plate. Silver is deposited on the base plate from this solution. While this makes a thin film that cannot be soldered, it can be plated and the plating soldered. This is not limited to silver, for other metals including copper, nickel, gold, and iron may be deposited in this manner. This lends itself to colored printed circuits allowing color-coding for identification purposes. Also, some metallic salts can be used to make resistors with this system.

Vacuum Processing

In this process, either of two methods are used. In one method, the coating metal is made the cathode and the surface to be coated is made the anode. A high voltage is applied in a vacuum and metal is emitted by the cathode and attracted to the plate where it is deposited through a stencil. Then the stencil is removed leaving the final metallic circuit.

In the other method, a metal is heated in a vacuum. The metal evaporates and is deposited on the stencil-covered base material.

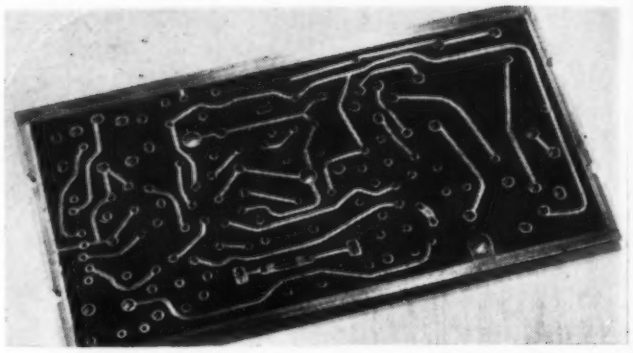
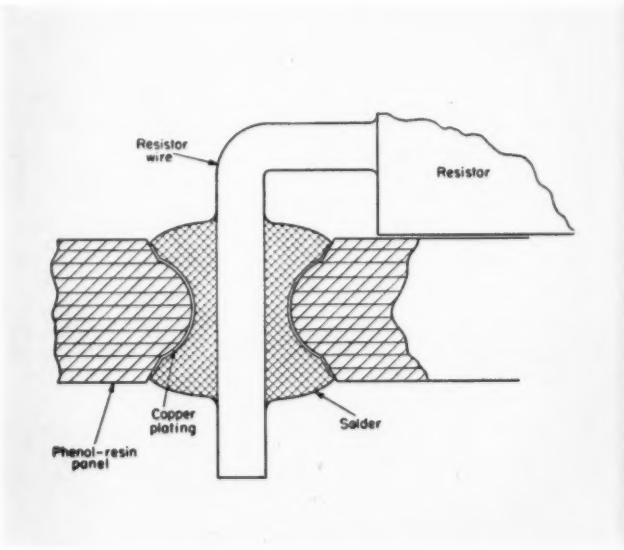


Fig. 2-8. Finished circuit made on molded board features recessed wiring and shaped holes (see below) that provide mechanical locking of components after soldering, thus eliminating need for crimping leads. (Photo courtesy Die-Form Circuits, Inc.)



Die-Stamping

There are several ways that die-stamping may be used to make a metallic circuit. It is possible to die-stamp the circuit pattern from a sheet of metal. Some connecting wires are left in place to hold the circuit together until components are soldered in place. Then the finished structure can be soldered into larger circuits.

Another approach uses much thinner metal foil die-cut to the desired configuration. This is then attached to a base material and components added to make the circuit complete.

A third method uses a die with its raised surfaces the image of the desired circuit. The die is used hot and presses the metal foil against the base. The heat causes the foil under the raised surfaces of the die to adhere to the base material forming the circuit.* Pure metallic silver is partly impressed into the base. This technique provides (1) greater wearing qualities (2) direct soldering without plating, and (3) increased resistance to oxidation.

* Special Products Division, Aerovox, Corp.

Dusting

In this technique a stencil is placed over the base plate and an adhesive is sprayed or painted on the surface. Then a metallic powder is dusted over the surface and adheres to the areas which were painted. Heat fuses the metallic powder. The powder also can be held to the proper circuit design pattern electrostatically.

Molding

Molding deserves special mention as it (1) is a fairly recent development, (2) promises to become increasingly important, and (3) usually combines both additive and subtractive techniques during production. Fig. 2-8 shows one such molded-panel circuit. Here the panel is formed in a die that makes the holes along with 0.015″ deep channels for the wires on one or both sides of the board. After a thermosetting adhesive is placed in the channels, copper is chemically deposited over the entire surface, including the sides of the holes. Next the board surface is masked by roller coating and copper is plated in the channels and holes. Solder is then plated on the wires and in the holes. Then the mask is removed and excess copper removed by electrolytic polishing. After flux is applied the panel is heat cured, which cures the adhesive, the panel and the flux.

Several methods of producing printed circuits have been discussed in this chapter. Specific information concerning a particular application can be obtained from the company sources indicated in this and other chapters.*

To be continued in the next issue

The chapters that follow include:

- Design factors
- Printed Components
- UHF Applications
- Circuitry, including Packages
- Production, including Automation
- Servicing

Conductive paints

General Cement Co., 919 Taylor Ave., Rockford, Ill. (silver $4.70 net, per ounce); Microcircuits Co., New Buffalo, Mich. (silver and copper, parts of kits); Handy & Harman, 82 Fulton St., New York 38, N. Y. (silver).

Resistance paints

Microcircuits Co., New Buffalo, Mich. (in kit form, approximately $10); Interelectronics Corp., 2432 Grand Concourse, New York 58, N.Y.

Bonded-sheet kits

Tele-Diagnosis Co., 155 W. 72 St., New York 23, N. Y. (kits $19.95); Techniques Inc., 135 Belmont St., Englewood, N. J. (kits, $4.95-$25); Consultants for Industry, 273 E. 175 St., New York, N. Y.; Harcon Electronikits, Brandywine, Md.

Bonded sheets

Mica Insulator Co., Schenectady 1, N. Y.; Continental Diamond Fibre Co., Newark 16, Del.—and others.

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10 MODERN DIGITAL TECHNIQUES

Our first issue introduced several binary codes, notation systems and double-dabble conversion. This issue we show how we put these techniques to work in multiplexing, counting, binary addition and multiplying. One basic logical element for digital technique is the matrix, a network that can be used as a digital decision-making element.

The Logical Network

Using the several methods explained previously for expressing any number in binary—that is, in terms of 0/1, yes/no, or on/off devices—let us see how we make decisions and perform "logic."

Perhaps the basic logical element is the matrix, which consists of rows of vertical wires and rows of horizontal wires, all insulated from one another, one line of which is shown in Fig. 2-A. It consists simply of a source of voltage, a resistor, a diode, and the 2-state element (switch). Note that a voltage appears at the output when the switch is in the 0 position; when the switch is in the 1 position, the voltage is bypassed to ground through the diode and practically no signal appears at the output. As a voltage output appears only when the switch is in the 0 position, the line is called the 0 line. In Fig. 2-B voltage will appear at output 0 when the switch is in the upper or 0 position and at output 1 when the switch is in the lower or 1 position.

A basic 4-decision diode matrix is shown in Fig. 3. It consists of two binary (0/1) switches and

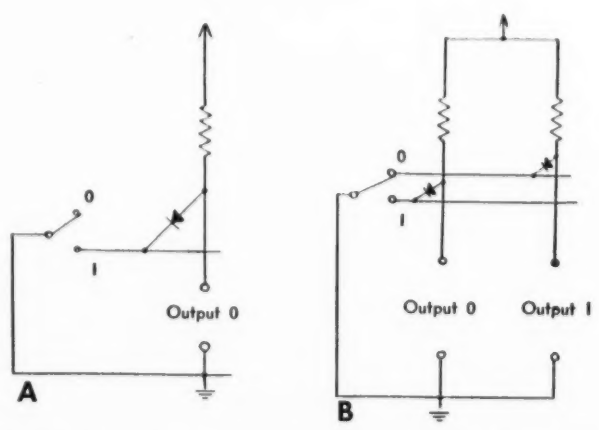


Fig. 2. A matrix consists of rows of horizontal lines and vertical lines, insulated from each other. Each vertical line is essentially a voltage divider controlled by a binary switch, whose position determines which output receives the signal.

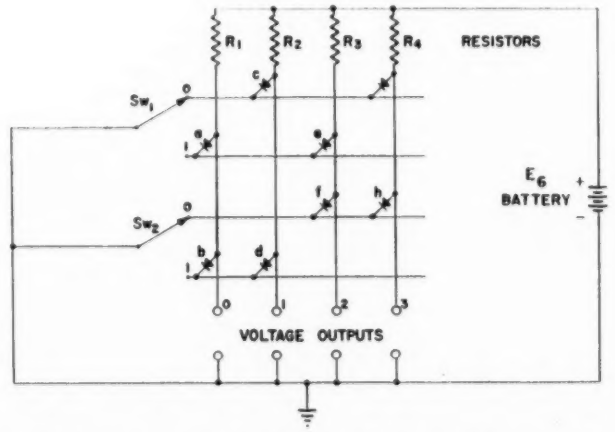


Fig. 3. A basic 4-decision diode matrix comprises 8 diodes and 2 switches. When switches are as shown, only line 0 is activated; and only output 0 shows output voltage. Matrix now responds only to 00 condition.

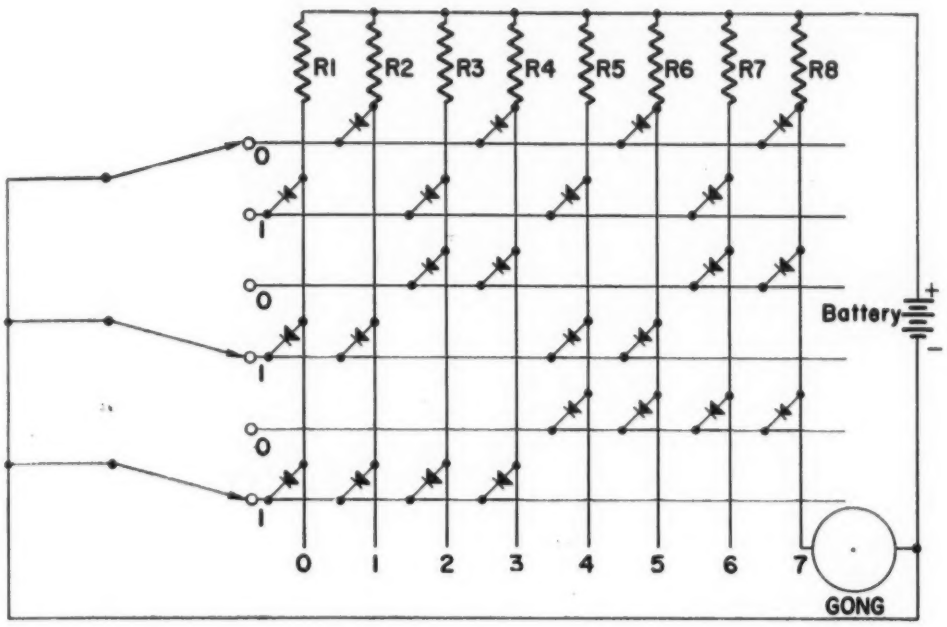


Fig. 4. Line 6 is energized if switches 2 and 3 are thrown to 1 position, representing binary number 110, or decimal number 6. However, all three switches must be in the 1 position before gong sounds. This would represent condition 111 (or decimal number 7).

8 diodes. When the switches are in the 00 position, as shown, only line 0 is activated.

When the top switch is thrown to the 1 position, only line 1 is activated; this is the 01 condition.

When the top switch is 0 and the lower is 1, only line 2 is activated; this is the 10 condition.

When the two switches are in the 1 position, only line 3 is activated; this is the 11 condition.

Note that this matrix decides which output will receive a voltage, depending on the 4 possible conditions of the 2 binary elements.

Fig. 4 shows how three switches can be used to represent any 1 of 8 possible conditions. Here the gong will ring only if the switches are in the 111 position. If they are in the 110 position (as shown), line 6 is active, but the gong will not ring.

If it is desired to perform some control action at, say, condition 0, 5, and 67, it is necessary to use 7 switches because the decimal number 67 is 1000011, which contains 7 bits. As only three conditions are to be monitored, it is necessary to use only three vertical matrix lines set up as shown in Fig. 5.

It is simple to design a matrix for any given condition. For example, to set the diodes in the 7-bit line for condition 5, all the switches are placed in the position representing 5 (0000101)—and then all the horizontal lines left open are jumpered to the vertical by diodes, as shown in Fig. 6.

Trunking the Matrix

A matrix line can be *trunked* by hooking a diode to *each junction* via another switch, as shown in Fig. 7. The diode can be connected to indicate any desired condition; hence the one line can be set for condition 0, then condition 1, then condition 2, etc. Depending on the time intervals between operation, and on the number of conditions to be monitored, it may be desirable to use a trunked matrix rather than an individual-line matrix.

Fig. 8 shows how 3 binary-wired switches can be used to trunk a matrix line to any value between 0 and 7. Note that the 3 switches, which are ganged, are wired in binary manner. Here flip-flops activated by pulses from a pulse generator (clock) are used to obtain high-speed response of the matrix line.

Multiplexing with the Matrix

Multiplexing is the term used to represent the time-sharing of a single transmission channel by several independent sources. For example, 50 or 100 data sources can transmit to one central receiver over one line by time-sharing the line and receiver, either *on demand* (as when one of the variables varies) or on a *fixed-time* basis.

Fig. 9 shows how the diode matrix can be used to multiplex a number of inputs. Depending on

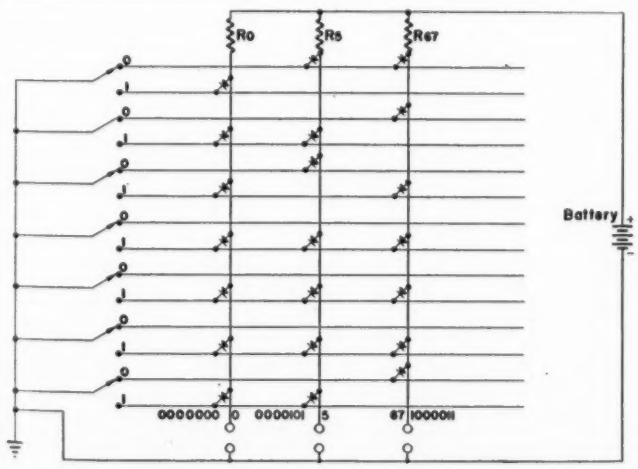
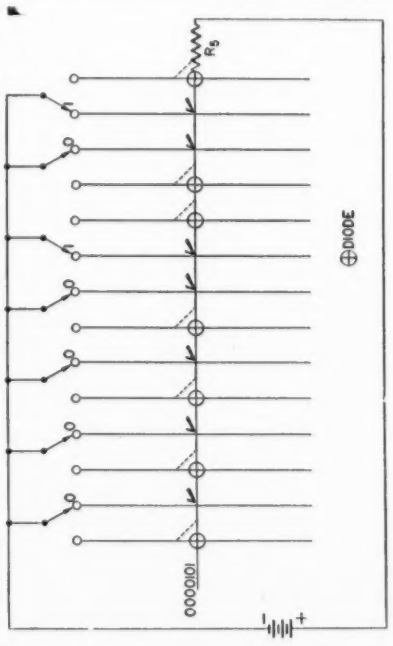


Fig. 5. Diode matrix for activating an output whenever condition 0, 5 or 67 occurs. Seven switches are required because the largest number (67) is represented in binary form by 1000011, which has 7 bits. Three vertical lines are used to represent the three conditions to be monitored.

Fig. 6. Placing diodes in matrix so that line is activated by number 0000101, representing condition 5. Reading upwards, the switches are placed in the 0000101 positions. All horizontal lines NOT connected to a switch are then jumpered to the vertical by diodes, as shown by dotted lines. Line will now have voltage on it when and only when the switches are in this 0000101 position, as desired.



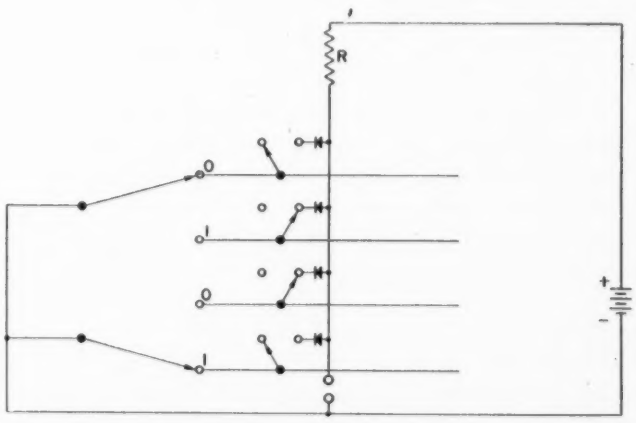


Fig. 7. Simple 4-count trunked matrix. A diode is connected to the vertical line above each horizontal line; and a diode-selecting switch is connected to each horizontal line. By changing the diode-selecting switches, the vertical line can represent any of the four conditions 00, 01, 10, and 11. As shown, line represents condition 10.

the 4 possible conditions of the input binary switches, any of the 4 inputs can be delivered to the output, depending on the position of the 2 input binary switches. The switches can be operated in succession at any desired rate if successive time-fixed multiplexing is desired; or the switches can be operated on demand if on-demand multiplexing is desired. Further, the switches can be replaced by high-speed electronic circuits (flip-flops) to attain a switching speed of microseconds.

Multiplexing with Relays

When commutation rates below 50 or 100 per second are satisfactory, it is possible to multiplex with relay-operated switches in a *Christmas-tree circuit*, as shown in Fig. 10. The binary signal is now the input to the relay solenoid, and each of the 8 inputs will be delivered to the output in turn as the relays step through conditions 000, 001, 010, 011, 100, etc., where a "1" represents a signal that energizes the solenoid.

A complete multiplexing and demultiplexing system can be obtained simply by using two sides of a Christmas-tree circuit and placing the relays in series, as shown in Fig. 11. The relays in series assure synchronism between the upper (multiplexing) circuit and the lower (demultiplexing) circuit.

The switches in the Christmas-tree circuit can be made to step through their 8 conditions by using a source of pulses (called a *clock*) that is fed to three flip-flops in series, with the first flip-flop connected to the first relay, the second flip-flop to the second relay, and third flip-flop to the third relay (Fig. 13).

COUNTING

In digital form, the signal is usually a series of pulses—and a host of basic problems can be solved simply by counting. There are three types of counting technique:

1. Total count, with no time measurement.
2. Count of events per unit time.
3. Time interval measurement between events.

The basic counting device in binary systems is a 2-state device, either electronic or magnetic. Transistors and magnetic cores are coming into wide use. However, all basic principles are illustrated clearly using the familiar flip-flop circuit.

The flip-flop (Fig. 12) is a 2-state device; one *or* the other of its 2 halves can be conducting, with the other cut off. Each input causes the stage to reverse condition, so that it flips and then flops between its two conditions. As it produces one output signal for every 2 input signals, it is basically a divider. If the left half of the tube is conducting, output 6 is low but the right half output 7 is a high voltage with respect to ground. Now if a negative pulse is applied to input 5, the left half cuts off making output 6 high, and the right half conducts making output 7 low. Note that a negative pulse applied to input 4 will cause a reversal in any case, but if applied to a grid already negative will have no effect.

Two flip-flops in series will count by 4; three in series will count by 8 (Fig. 13). The circuit can be made to count by any number simply by using feedback to appropriate stages, as shown in Fig. 14.

The Gated Counter

A difficulty associated with the preset counter is that there is some small time delay in the circuit. Thus, if the 100th count is needed to trigger a control circuit, the 100th pulse is delayed by the time required for flip-flop operation. This is overcome by gating a stage so that only the 99th pulse will open the gate, permitting the 100th pulse to pass through the gate undelayed, and resetting on the same pulse for the next count of 100.

Totalizing, EPUT, and X/Y Counting

The combination of a gate, a clock that establishes a time base, and a counter permits great flexibility in count totalizing, frequency measure-

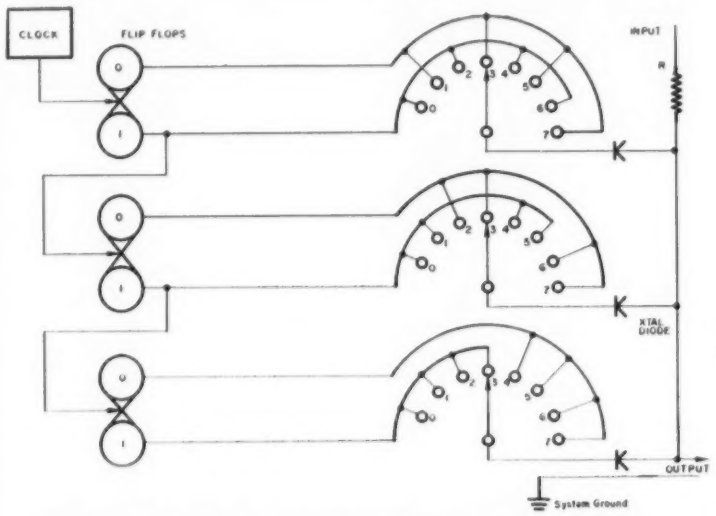


Fig 8. Use of binary-wired switches to trunk a matrix line at any value between 0 and 7. At position shown, line will activate only when input (number of pulses from clock) is 3—that is, 011 (least significant bit is at top).

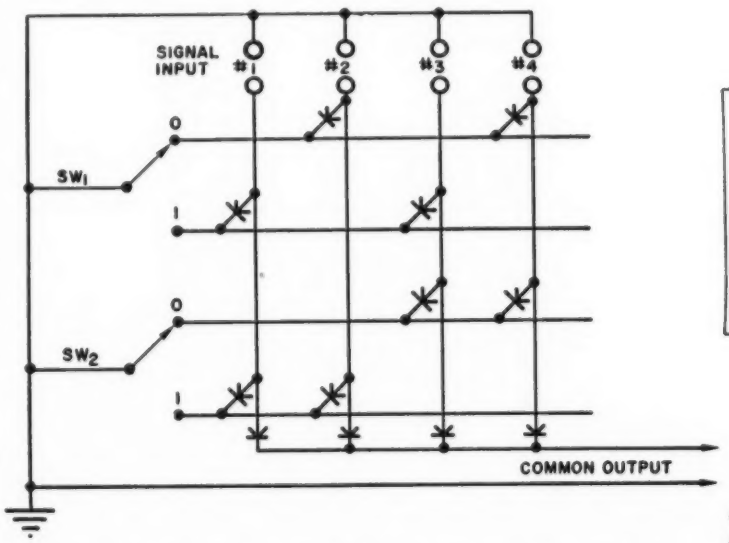


Fig. 9. In fixed-time multiplexing by a diode matrix the matrix switches are operated into positions 00, 01, 10, and 11, in succession. The common output thus receives the four separate input signals successively, but at different times.

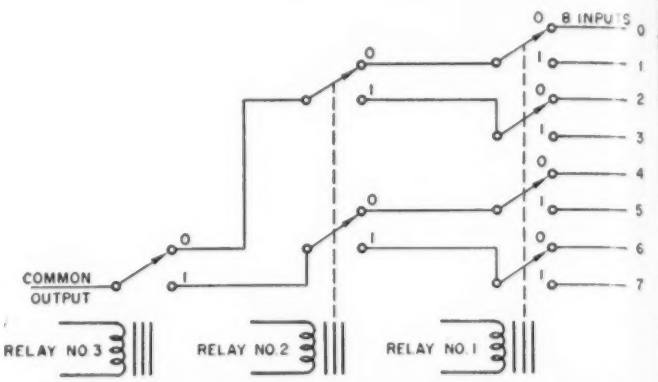


Fig. 10. Typical Christmas-tree relay circuit for electromechanical multiplexing of 8 channels. Relays are shown in position 000, and input 0 is delivered to output. First input pulse would trip relay 1 (corresponding to condition 001) and deliver output 1 to common output. Similarly, if relay 3 only is operated (on input 100) input 4 is connected to output. With digital input 111, channel 7 is connected to output.

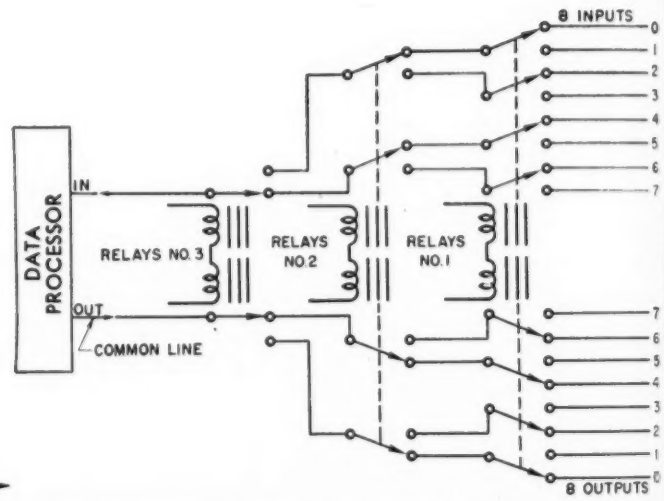


Fig. 11. Complete multiplexing and demultiplexing system for eight channels. Christmas-tree circuit at top performs the multiplexing and sends the input channels to the common output line in succession. Similar Christmas-tree circuit at bottom performs demultiplexing to send input 0 to output 0, input 1 to output 1, etc. Relays for upper and lower tree circuits are in series to assure synchronism.

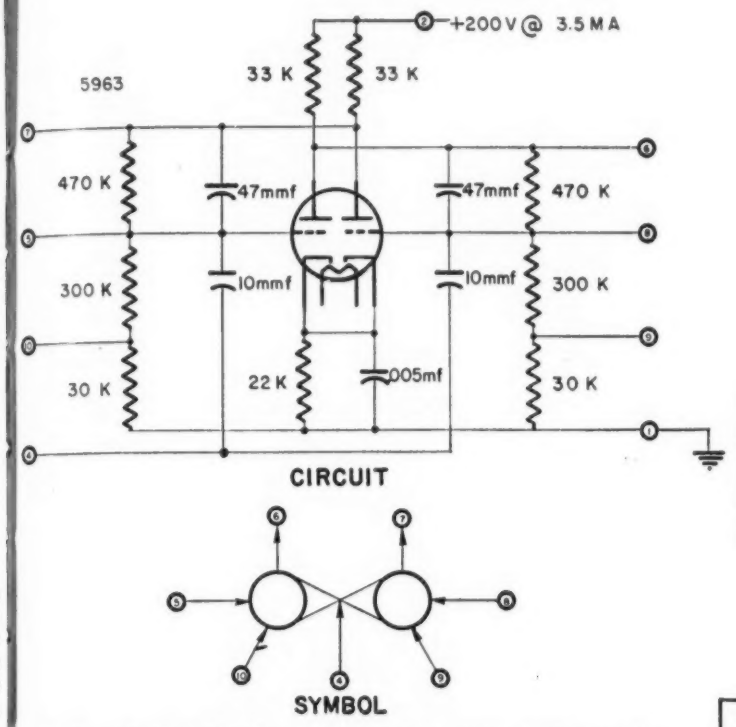


Fig. 12. The flip-flop is the basic 2-state device in electronic counting and computing circuits. The numbers shown refer to pin connections on one type of available plug-in unit.

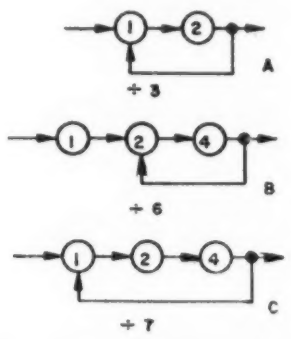


Fig. 14. Feedback from later to earlier stages is used to make the circuit reset on any given count. For example, circuit A will reset on every 3rd count and thus divide by 3; circuit B divides by 6; circuit C by 7.

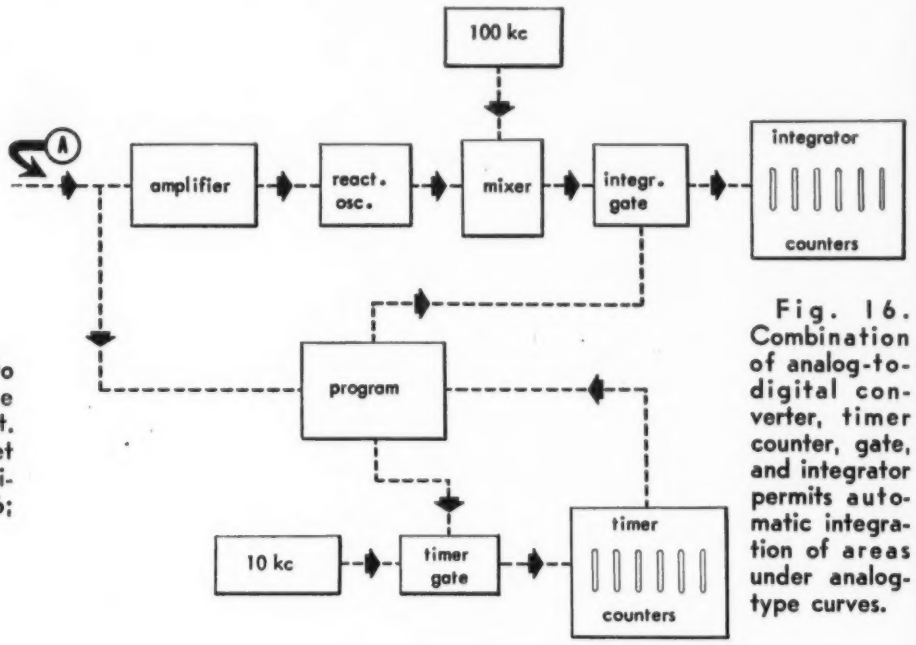


Fig. 16. Combination of analog-to-digital converter, timer counter, gate, and integrator permits automatic integration of areas under analog-type curves.

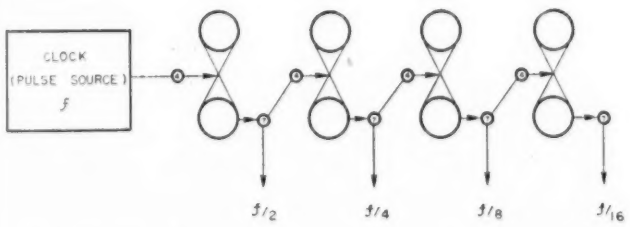


Fig. 13. Flip-flops in series count, or divide, by 2, 4, 8, 16, etc. For example, in circuit shown there would be 1 output pulse for every 16th input pulse.

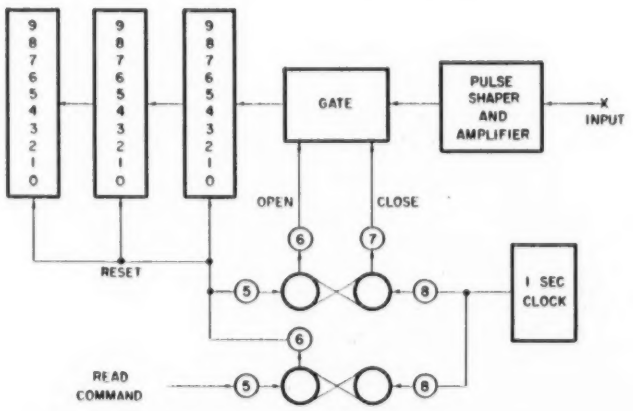


Fig. 15. Combination of a gate, a clock, and decade counters permits various modes of operation—totalizing, totalizing events per unit time, ratio measurement, time measurement, frequency measurement, etc.

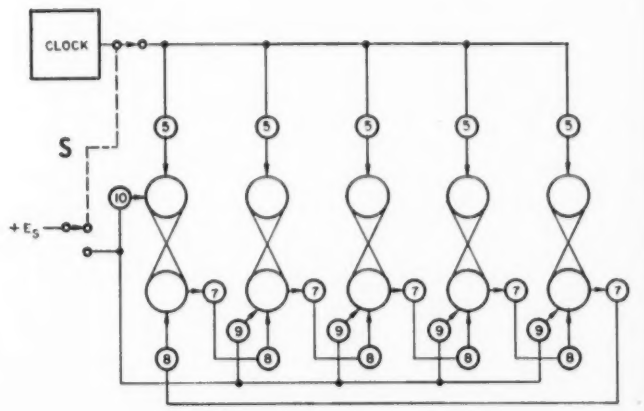


Fig. 17. Ring counter uses the slight delay in flip-flop action to enable each flip-flop in succession. Each successive clock pulse thus changes the state of one flip-flop, in succession.

ment, totalizing the number of *events per unit time* (referred to as EPUT* operation), etc., as shown in Fig. 15.

For example, for events-per-unit-time operation it is necessary only to gate the counter in fixed time intervals; for *ratio* or *X/Y* operation it is necessary only to gate the counter by the Y signal; a movable decimal point in counting can be effected simply by changing the clock rate by a factor of ten. This flexibility permits, for example, flow measurement in fuel mixture ratio, volumetric units per unit time, gravimetric units per unit time, etc., etc.

Perhaps the ultimate in flexibility, opening up still other and newer fields of analysis via digital techniques is the inclusion of automatic analog-to-digital conversion plus integration (count totalizing) in one small unit, as shown in Fig. 16.

Here an analog signal applied to the input causes a reactance oscillator to change frequency by a proportional amount (10 kc per volt input). This change in frequency is detected by heterodyne techniques and converted into pulses which pass through a gate to the counters. The time interval for which the gate is open is determined by a time-base circuit comprising a timed gate and a programmer. Thus the area under any analog-type curve can be measured rapidly and automatically to a high accuracy.

Counting Rings

Another useful electronic counter circuit is the *ring counter*, shown in Fig. 17. This is a simple ring-of-five counter.

*EPUT is a registered trademark of Berkeley Div., Beckman.

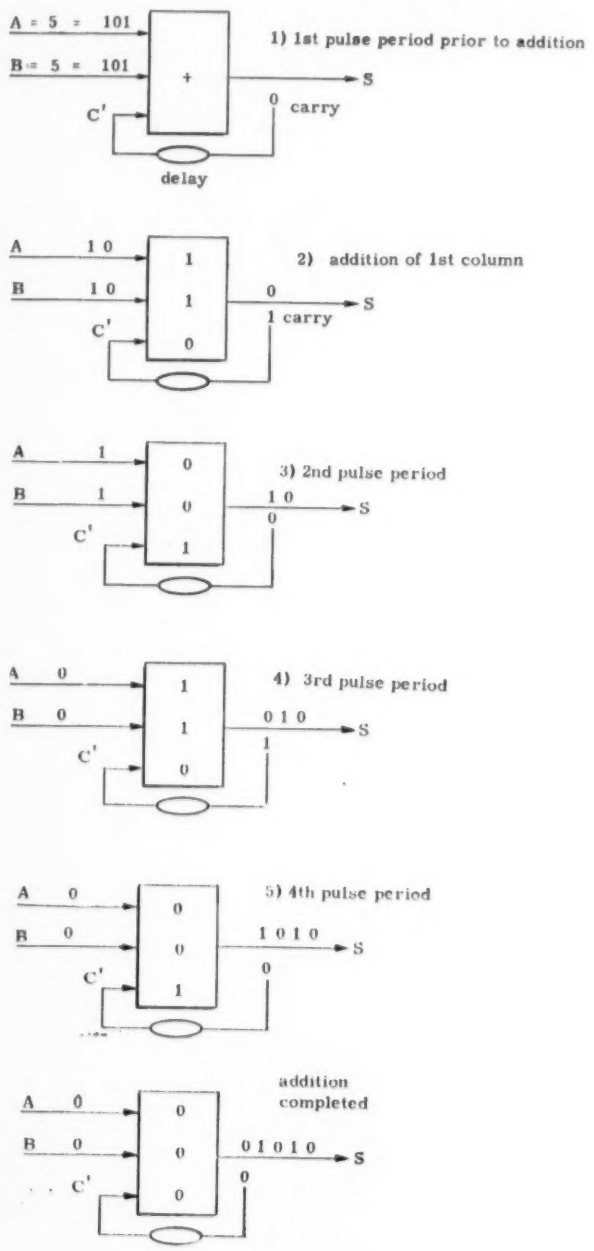


Fig. 18. Serial addition of two binary numbers 101 and 101.

This circuit uses the slight delay between input and output of a flip-flop to act as a memory for a carry pulse. When the circuit is first turned on, the double-pole double-throw pushbutton switch (S) is depressed. This action first disconnects the clock and then, by means of a large positive voltage applied to preset pin 9 of the last four flip-flops, these counters are reset with left halves cut off (or 0 state) so that the negative clock pulse input (to pin 5) does *not* initiate a change of state in any of these counters. However, the first flip-flop on the left is preset with its output pin 7 high (in the 1 state). This means that when the pushbutton is released, the clock finds the first flip-flop with the right half conducting (refer to Fig. 12) so that the first negative clock pulse resets this first counter stage. Due to the slight delay in the flip-flop, by the time output 7 of the first counter falls to pass on a negative carry pulse to the second counter, the clock pulse on its input 5 is over. The second flip-flop is then changed over by the carry pulse with its output 7 high (1 state). The 1 state has therefore been shifted from the counter on the left to the second counter. The second clock pulse now by similar action shifts the 1 state in the second flip-flop to the third one. With the fifth clock pulse, the 1 state is transferred back from the rightmost counter to its original position in the leftmost counter. This ring action continues as long as the counter bank is supplied with power. Such ring circuits have many uses, including driving an electronic multiplexer without a matrix.

ARITHMETICAL OPERATIONS

Binary techniques for accomplishing arithmetical operations will be illustrated by examples in serial and parallel addition and in parallel multiplication.

Binary Addition—Serial Method

The most common method for performing binary addition is called the *serial* method. By this method, two binary members, such as 101 and 101, are added by commencing with the right-hand column and progressing to the left, carrying a 1 to the next higher column when a (1 + 1) addition is indicated (Fig. 18). The two numbers A and B can be thought of as two pulse trains entering an adding device. The 0's represent *no pulse* and the 1's represent a pulse. The pulse trains A and B are synchronized so that corresponding columns enter the adding network precisely simultaneously. The two numbers "march" into the adder at the rate of, say, one column per microsecond. As will be shown, the adding device must be a digital network arranged to perform the addition defined previously in this discussion (that is, 1 + 1 = 0, carry 1).

A "carrying" circuit supplies a third pulse, input C'. The "carry" signals are fed back from the output through the one-pulse-period delay. The "Carry" digit is thus added to the next higher-order column, and is indicated with a prime sign (C') to show that it is generated one-pulse-period earlier than the A and B inputs. Fig. 18 shows how the two digital numbers A and B are added in four pulse periods.

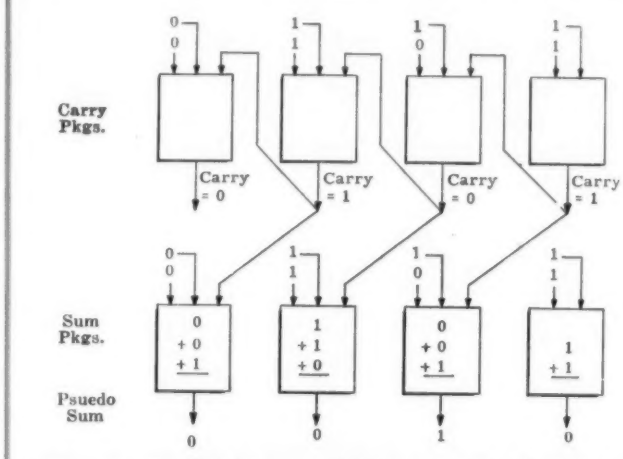


Fig. 19. Parallel binary addition at end of first pulse for addition of two numbers 111 and 101.

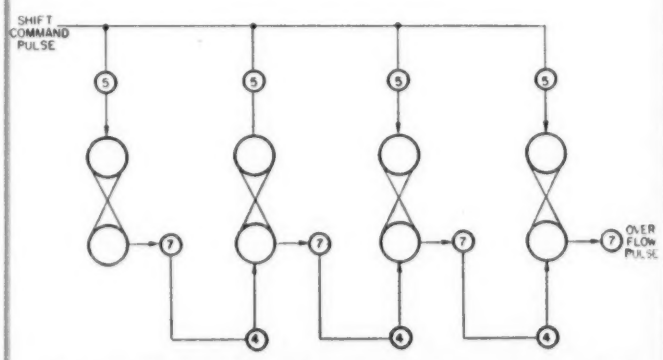


Fig. 20. Right-shift register comprises a series of flip-flops. When a "shift" command pulse is received, only a flip-flop in the 1 state and/or to the right of a flip-flop in the 1 state will change state.

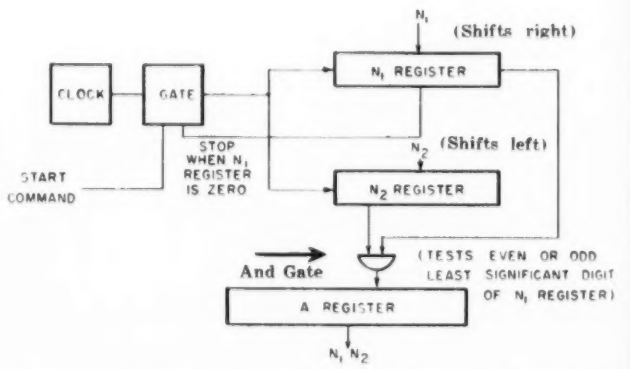


Fig. 21. Block diagram of system for parallel multiplication.

Binary Addition—Parallel Method

The serial method of addition requires one more pulse period than there are columns of digits to be added. If a faster addition is required, the *parallel* method (Fig. 19) can be used.

The parallel method requires one set of carry

and sum packages, each containing as many adding devices as there are columns to be added, plus one. Sum packages are simple flip-flops while carry packages are single-stage dividers. The two numbers to be added enter the parallel adding system of Fig. 19 at the first pulse period only and appear simultaneously at the inputs of the corresponding carry and sum packages. A pseudo sum then appears at the output of the sum packages, while the output of each carry package is a 1 if a carry has resulted, or a 0 if not. The output of each carry package is fed down to the next left sum package where it may change the pseudo sum. The same carry output is also fed to the next left carry package where it may, or may not, produce a carry. This is automatically repeated until no more carries are generated. Whenever the pseudo sum receives no change from any carry package, it has become the final *true* sum.

The following example shows how this is done:

Pulse 1	0111	Number A, 7
	0101	Number B, 5
	0010	Pseudo sum #1
Pulse 2	1-1-	Carry #1
	1000	Pseudo sum #2
Pulse 3	-1--	Carry #2
	1100	Pseudo sum #3
Pulse 4	----	Carry #3 (None)
	1100	True sum (No change), 12

The time required to perform the addition depends on the "pulse period" (or inherent reaction rate built into the package) and the number of carries, which can be as many as there are places in the answer.

In the longest case, the carry may have to be cleared throughout the entire number, as follows:

Pulse 1	11111111	Number A, 255
	-------1	Number B, 1
	11111110	Pseudo sum #1
Pulse 2	------1-	Carry #1
	11111100	Pseudo sum #2
Pulse 3	1	Carry #2
		. . . and so on . . . to
	10000000	Pseudo sum #7
Pulse 8	1-------	Carry #7
	100000000	True sum, 256

Here nine delay intervals would be required.

In the shortest case, only two delay intervals are required:

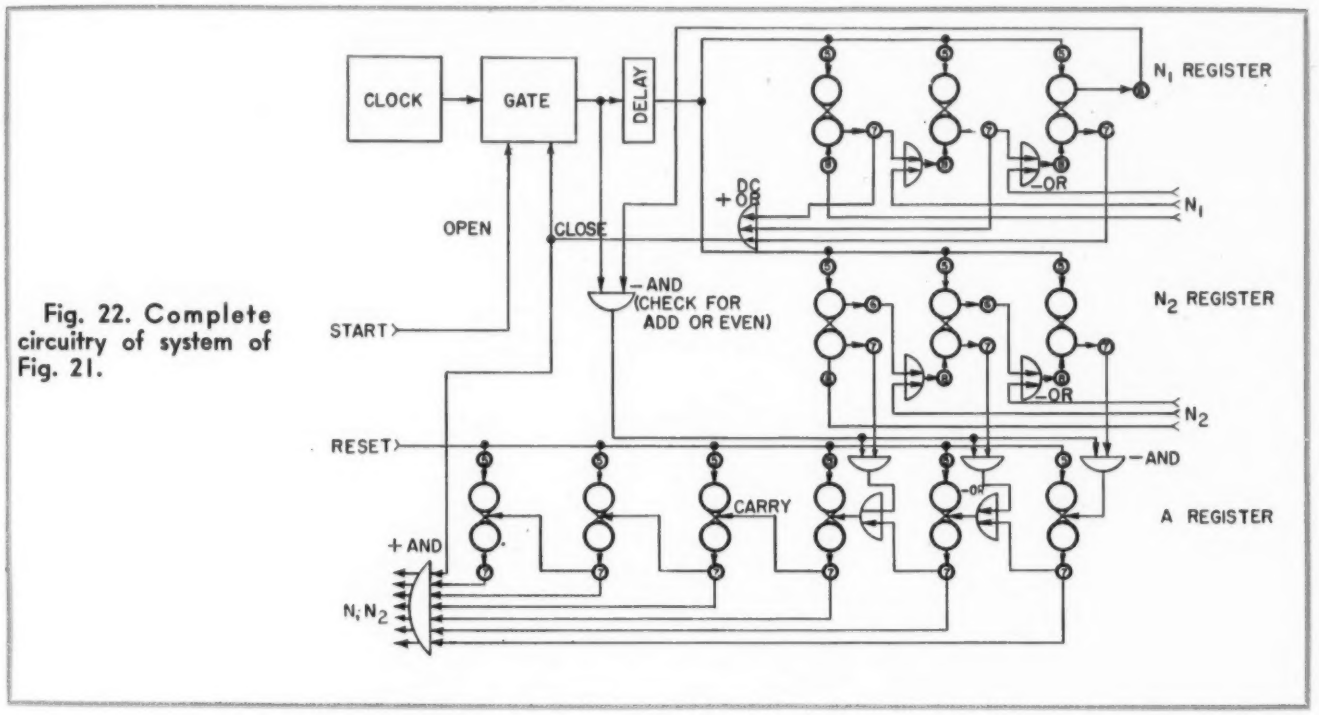


Fig. 22. Complete circuitry of system of Fig. 21.

Pulse 1	1111111	Number A, 127
	1111111	Number B, 127
	0000000	Pseudo sum #1
Pulse 2	1111111-	Carry #1
	11111110	True sum, 254

Electronic Multiplication

Multiplication, as was shown in Chapter 1, is essentially a series of shifts and additions in binary as in decimals. In principle then, one can multiply simply by adding. However, a neat way of multiplying binaries consists of the *halving and doubling technique.*

If we wish to multiply the decimal numbers 7 and 3, let us continue to halve either number (7), throwing away any remainder and simultaneously doubling the other number (3). In chart form, this would look like this:

Halve	Double	Left column is:	Retain
7	3	(odd)	3
3	6	(odd)	6
1	12	(odd)	12
0	24	(even)	0
		Product is	21

Examining the left-hand column, wherever the number is odd, retain the number in the right-hand column. (Consider 0 to be even.) If we follow this convention and add the numbers retained, we find that we have the sum of 3, 6, and 12, which is 21, the desired product.

If we apply this technique to the product of 13 and 3 we get:

		Left Column is	Retain
13	3	(odd)	3
6	6	(even)	0
3	12	(odd)	12
1	24	(odd)	24
0	48	(even)	0
			39

The product is 39.

What makes this particularly attractive in a binary computer is that one can halve a number and throw away the remainder by the simple trick of *right-shifting* it, thus:

111 = 7
11 = 3
1 = 1
0 = 0

Similarly, one can double a number by *left-shifting* it. Thus:

011 = 3
0110 = 6
1100 = 12

It is also evident that a binary number always can be tested for oddness by looking at the least-significant bit—if the number is odd, that bit will always be occupied by a one. Thus we see that simply by use of left shift, right shift, and testing the least-significant bit, we can rapidly multiply numbers in binary code.

Multiplication Circuitry

In order to multiply two binary numbers, we must store them in registers, right-shift one register, left-shift the other, and test the least-significant bit in the right-shift register. Fig. 20 shows a circuit for a right-shift register. The count (or number) in the register is indicated by the state of the flip-flops. Upon receipt of a "shift" command pulse, a pulse is carried to the next stage if and only if a count was stored in the previous stage.

Fig. 21 shows a system for *parallel multiplication*. It has three registers, two of which contain the numbers to be multiplied and one to store the sums. The registers are shift registers. If we wish to multiply 7x3, as previously suggested, the 7 is stored in the N_1 register, which right shifts to halve the numbers; the 3 is stored in the N_2 register, which left shifts to double the numbers. The "A" register is to contain the product.

After the numbers are introduced, we test the least-significant bit by using the "and" gate which transfers the count standing in the N_2 register into the "A" register only if the count in the N_1 register is odd. We then left-shift the N_2 register, right-shift the N_1 register, test its last bit, and add the new N_2 count to the count stored in the A-register (if the N_1 register count is still odd). This is repeated to completion, which is indicated when a 0 count stands in the N_1 register. The complete circuitry for performing these operations is shown in Fig. 22.

The time to make a multiplication is thus:

If it takes one microsecond per operation, a multiplication of a 10-bit number would take twenty microseconds.

Note also that the product occupies more register space than either of the two numbers being multiplied, and the "A" register must be made large enough to accommodate the largest number of bits that can be generated. Thus, a 20-bit "A" register is needed for multiplying two 10-bit numbers. For addition of two 10-bit numbers, however, the "A" register need only be eleven bits long. Ordinarily, if the result exceeds the size of the register, an overflow light is energized, and the computer is automatically stopped.

Acknowledgement

Fig. 16 is by courtesy of Allegany Instrument Company; Figs, 18 through 21 courtesy of Computer Control Company.

In our next issue we explain techniques used by medium-sized general-purpose digital computers, including programming methods used by each.

MA Bio-Bits

The purpose of these short biographical sketches is to provide our readers with an insight into the lives of some of the military and scientific leaders now guiding the development of automation for the U. S. Armed Forces. This month we are happy to introduce Mr. Ernest A. Goetz, Assistant Chief Engineer, Arma Division, American Bosch Arma Corp.

ERNEST A. GOETZ

"His ruling passion is simplicity." This is often said of Ernie Goetz. It characterizes not only the business life, but also the home life of Ernie, one of the scientific leaders now guiding the development of automation for the different branches of the U. S. Armed Forces.

The notion of the good life and what men live for is deeply embedded in the Goetz home base . . . a gardened, dwarf-orcharded three-quarter-acre at Glen Head, Long Island, N. Y. Here, the persuasions of the humanities so supercede those of the scientific as to make one certain indeed that Ernest Jr. (8) and Mary, Margaret and Agnes Patricia (respectively 5½, 4 and 1) would little believe their dad has any more serious obligation than to take them picnicking come Saturday. For, business never enters here. Simplicity at home is typified in a husband and father with hobbies aplenty but controlled for time to have fun with his wife and children. Ernie paints in oil—landscapes and portraits—collects and remodels guns, does color photography and is expert in woodworking, that basic essential of young marrieds with an expansible ranch house and bent on raising a family.

Born in Brooklyn, N. Y., in February 1920, Ernest A. Goetz chose Brooklyn for his education and also the start of his career. He received his B.E.E. from Pratt Institute in 1941 and immediately joined Arma, then located in Brooklyn. By subsequent night courses he acquired his M.E.E. in 1947 from Polytechnic Institute of Brooklyn, and since has done further graduate work in the field of communication theory and mathematics.

Mr. Goetz's entire career has been in research and development concerned with advanced systems engineering for our modern, complex fighting machine. His numerous personal contributions are related to many of the Arma systems for the military, including the operational B-52 defensive system, an inertial guidance system being developed for the Air Force intercontinental ballistic-missile program, defense systems for USAF long-range bombers, automatic gun-laying systems for main and anti-aircraft batteries, navigation systems for the Navy, fire control and navigation systems for the Army, pro- and anti-submarine warfare systems, aircraft navigation systems, and precision automatic controls for atomic power installations.

The research, development and engineering on these systems has carried successively more important roles for Mr. Goetz. Like most of his associates he started as a junior engineer. By upward steps he became an assistant engineer, engineer, head of the Servo Department, head of the Computer Department, administrative director of the Research and Development Section, assistant chief engineer of the Research and Development Section. In February, 1956, he became assistant chief engineer, Missile Guidance Section, where some 500 professional personnel, engaged in one of the most challenging projects of the era, are under his direction. He is responsible for all engineering efforts on a guidance system for an ICBM.

Along the way, by work on the actual development of such critical system components as analog and digital computers, gyroscopes, accelerometers, inertial platforms, servomechanisms, electromagnetic and electronic components, radar, electronic countermeasures and infrared, he has participated with Arma Division in advancing the capabilities of many weapons systems. These include systems for submarines, surface ships, strategic and tactical aircraft, AEW aircraft, penetration and bombardment weapons, countermeasure equipments, tactical and strategic surface-to-surface missiles and air to surface missiles tanks, heavy artillery and other land, sea, and air vehicles.

Of his present job he says "I enjoy it because it continually challenges me to master the exact definition of objective, and, with respect to all on the project, to develop enthusiasm and proper motivation."

Mr. Goetz is a member of the Air Force Association, American Ordnance Association, United States Naval Institute, American Institute of Electrical Engineers, Sigma Xi, Tau Beta Pi.

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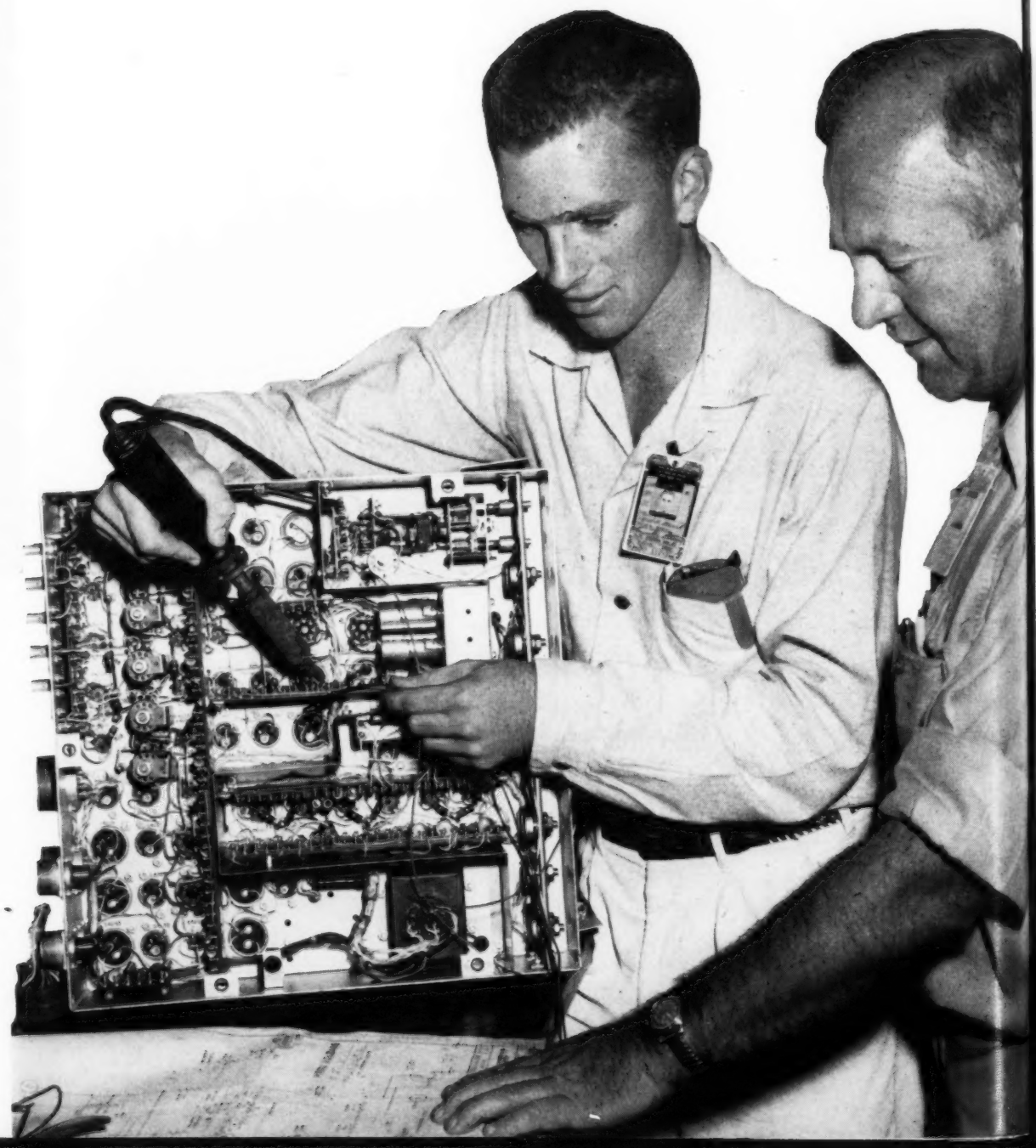
FOREWORD

Guided missiles are the product of a relatively new and undeveloped technology which places exacting demands on the ability of engineers and scientists. The development and establishment of techniques for evaluation of guided missiles entail scientific problems without precedent in any field. Problems encountered to date pale beside the magnitude of those now being approached.

The critical shortage of professional scientists and engineers has made the recruiting and retention of such talent a serious continuing problem. The increasing urgency of this problem has led the Naval Air Missile Test Center to establish a Student Engineering Development Program wherein local high school graduates with high engineering potential are developed into the type of exceptional engineering talent needed by the Center. In the course of the program, the students attain the theoretical and practical background necessary to meet the challenge of guided missile research, testing, evaluation and development.

D. G. DONAHO
Captain, U. S. Navy
Commander,
U. S. Naval Air Missile Test Center

NAMTC
Student Engineering D



PRACTICAL WORK with electronic equipment is introduced early in the student engineering program.

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Development Program

STUDENT ENGINEERS analyze and repair electronic gear in the well-equipped shops of the Technical Service Department.

STUDENT ENGINEERING DEVELOPMENT (SED) PROGRAM is a five-year plan for developing engineering talent for the U. S. Naval Air Missile Test Center, Point Mugu, California. The plan combines a three-year cooperative work-study program leading to an Associate-in-Arts degree and a two-year scholarship program leading to a Bachelor of Science degree. It also provides an opportunity for a student to earn a Master of Science degree during his first three-year work period at the Naval Air Missile Test Center.

The SED program, as proposed and initiated by Commander Leonard L. Brannan, Industrial Relations Officer, Naval Air Missile Test Center, Pt. Mugu, is a type of grass-roots program that contains the germ of a reproducible idea—one that could well be emulated elsewhere by laboratories, government, research foundations and business organizations. (The plan has certain features in common with promotional training programs already used by IBM and other nationally-known industrial organizations).

The specific objectives of the SED Program now in operation at the NAMTC are:

1. To attract, motivate, and provide opportunities for competent young people of the local community to enter the field of engineering.

2. To develop young people of high potential, selected from the high schools of the local community, into capable professional employees by means of formal academic training and planned work experiences under professional engineers.

3. To provide the Naval Air Missile Test Center with a continuing supply of competent engineering personnel rooted in the local community and devoted to a career in guided-missile engineering at the Center.

4. To permit the student to earn while learning and to get first-hand experience in his chosen work.

5. To give the student an opportunity to fulfill his military obligation without interruption to his career in engineering.

As shown in Chart I, the SED Program comprises three phases, each being an important step in the professional advancement and growth of the student.

Phase I

Phase I embraces a three-year work-study program in cooperation with Ventura College. The student is initially employed during the first summer as a Student Trainee, GS-2, on a full-time basis at full pay. During the second and third summers he participates in military reserve training.

During the first three academic years, the student attends school one-half day and works at the Center one-half day for which he is paid in his grade, on a part-time basis, for the actual hours worked. The academic portion of this phase covers the first two years of an engineering curriculum leading to the Associate-in-Arts degree. The work portion consists of work assignments of increasing technical difficulty and responsibility, rotated among the different departments of the Test and Evaluation Facility of the Test Center.

Phase II

Phase II provides for full-time on-campus development with pay at the grade levels of GS-4 and GS-5 at either the Berkeley or Los Angeles Branch of the University of California. The student who demonstrates his proficiency both on the job and in the classroom during the first phase of the SED Program and is able to meet admission requirements of the University of California is given on-campus training for the junior and senior years of the engineering curriculum, for which he is obligated to fulfill a work period as explained under Phase III. During the summers he is employed fulltime at NAMTC.

Phase III

Upon graduation and after receiving the Bachelor of Science degree in engineering, the student is assigned professional engineering duties at the Naval Air Missile Test Center as a regular member of the technical staff. In Phase III, the student is obligated for one year of Federal Service for the first year of scholarship, and two years for the second, making a total of three years of obligated service to the Government for the training received during the second phase of the SED Program.

During the period of service under Phase III, the student is given an opportunity to take advanced work at the Center leading to the Master of Science degree.

After the young engineer has been aboard the Center for three years as a permanent employee, he becomes eligible to compete for a number of scholarships in technical and management fields.

Unlike cadets at Armed Forces Service Acadamies, who may be "washed out" by relatively minor physical defects, SED students are graduated as engineers unless disabled by serious health defects.

Students and SED

The program offers many advantages to the student.

The varied activities in the technical departments of the Center make it possible for a student to gain experience in research, design, development, testing, and evaluation of guided missiles and their components. By rotating on job assignments (Chart II) he determines the type of work best suited to his individual aptitudes, interests, and career objectives. His firsthand observation of the professional activities

CHART I—STUDENT ENGINEERING DEVELOPMENT PROGRAM

Phase I Work-Study Ventura College

FIRST YEAR 1 JUL-30 JUN		SECOND YEAR 1 JULY-30 JUN		THIRD YEAR 1 JUL-30 JUN	
Summer	School Year	Summer	School Year	Summer	School Year
Work	STUDY ½ DAY WORK ½ DAY	Work or Military Training	STUDY ½ DAY WORK ½ DAY	Work or Military Training	STUDY ½ DAY WORK ½ DAY
SALARY RATE GS-2 $2,960 (Part Time Pay)		SALARY RATE GS-3 $3,175 (Part Time Pay)			

▶ Associate Arts Degree

Phase II Scholarship UCLA or UCB

FOURTH YEAR 1 JUL-30 JUN		FIFTH YEAR 1 JUL-30 JUN		
Summer	School Year	Summer	School Year	
Work	FULL TIME STUDY JUNIOR YEAR	Work	FULL TIME STUDY SENIOR YEAR	OCS or USNR OPPORTUNITY
GS-4 $3,415		GS-5 $3,670		

▶ Bachelor of Science Degree in Engr.

Phase III Obligated Work Period. Study Optional

SIXTH YEAR 1 Jul-30 Jun	SEVENTH YEAR 1 Jul-30 Jun	EIGHTH YEAR 1 Jul-30 Jun
WORK (Advanced Study) 6 units	WORK (Advanced Study) 10 Units	WORK (Advanced Study) 4 Units and Thesis
GS-5 $4,480; GS-7 $5,335	GS-9 6,115	GS-11 7,035

▶ Master of Science Degree

CHART II—TYPES OF TRAINING

	Training Period	Academic Courses	Practical Work Experiences
Phase I	First Year	Engineering Orientation Slide Rule Analytical Geometry Calculus Drafting Mechanics-Prop. of Matter Humanities & Liberal Arts	Machine Shop Practices Metal Shop Practices Foundry & Pattern Shop Practices Heat Treatment and Structural Fabrication Processes Engineering Drafting—Blueprint Processes Practical Application of Mathematics and Physical Sciences Familiarization—Electronic Systems and Equipment
Phase I	Second Year	Engineering Mathematics Electricity and Magnetism Heat, Light, Sound Humanities and Liberal Arts	Preparation of Reports, Graphs and Mathematical Computations Testing Procedures and Data Assessment Testing Techniques on Practical Problems Launchers and Environment Factors Standard Laboratory Test and Measurement Equipment Construction, Maintenance & Modification of Electronics Equipment Photo-Optical Processes
Phase I	Third Year	Chemistry Surveying Engineering Materials Graphics Statics Humanities and Liberal Arts	Familiarization with Target Aircraft Launching and Handling of Missiles Materials Procurement and Stock Handling Report Editing and Writing Missile and Component Checkout Publication and Technical Visual Aid Design
Phase II	Fourth and Fifth Years	Circuit Analysis Electrical Machines Engineering Dynamics Fluid Mechanics Engineering Laboratory Thermodynamics Strength of Materials Professional Duties—Engineer Specialization Electives	Ordnance Handling Serviceability Monitoring Techniques Testing of Air Frames and Structures Aeronautical Engineering Design Electronic Engineering Design Mechanical Engineering Design Planning, Estimating and Scheduling

and ethics of a group of technically trained personnel encourages him to aspire to participate in these activities following graduation.

The financial assistance offered the student allows him to devote full time to the satisfactory completion of an engineering curriculum. Another advantage to the student is the opportunity of living at home during the work-study phase of the program. The training and experience received through the SED Program tends to instill a feeling of confidence and a healthy outlook for a successful career upon graduation, when young men are usually faced with a strange job in a strange community.

The Navy and SED

The Navy feels the need for thoroughly trained engineers to meet the increasing demand for technological advancement. In addition, the Navy desires appropriate placement of graduate engineers in proper jobs. SED serves as a medium of acquiring thoroughly trained engineers and placing them properly.

The Navy gets the opportunity to observe and aid in the development of promising students, while training them in the particular methods used at the Center. Upon graduation the young engineer needs little "breaking in." The SED graduate-engineer enters into full-scale production without the usual non-productive learning period, or delays in assignment while his security clearance is being processed.

Promotional Opportunities

The student advances in grade and salary as he progresses in the SED Program, as shown in Chart I.

Upon graduation the young engineer or scientist returns for duty at the maximum in-grade step of GS-5. After a minimum time of three months, he may be advanced to the GS-7 grade (top step) by allowing credit for professional experience as an engineer and appropriate experience as a Student Trainee, GS-5.

Scholastic Qualifications

Applicants are limited to the graduating classes of the local high schools of Ventura County, California. They must be 16 years old and have completed a pre-engineering college-preparatory curriculum, with an average grade of "B" or better.

Entrance requirements of Ventura College for its pre-engineering curriculum, and current Civil Service requirements for appointment to the position of Engineering Aide, GS-2, must be met.

Military Reserve Training

The student has an opportunity to participate, if physically qualified, in a military training program to meet his military obligation while pursuing the Student Engineering Development Program.

It is planned that the second and third summers, as indicated in Chart I, will be be used for active military training so that this training combined with 7½ years

STUDENT
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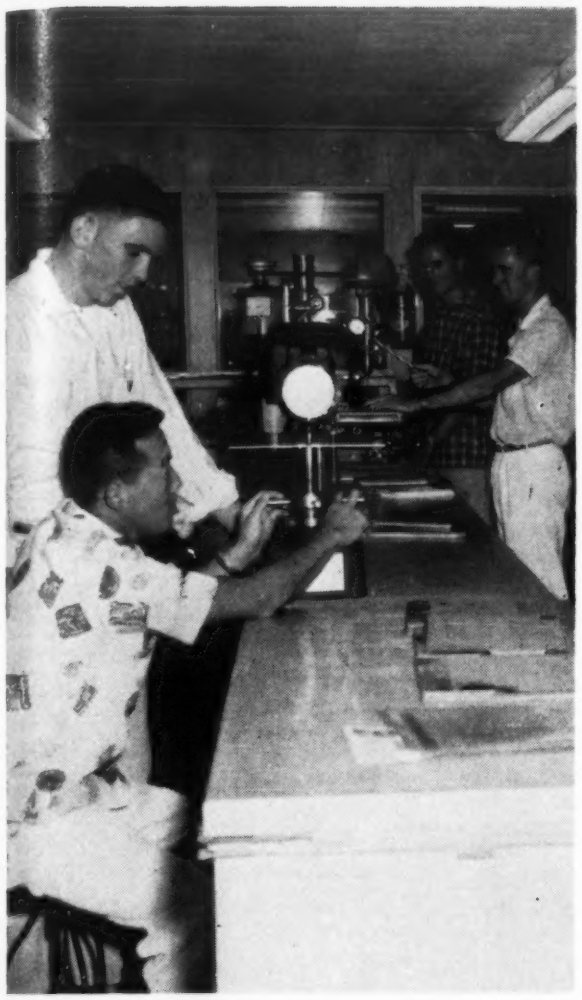


STUDENT ENGINEERS test metal hardness in the metallurgy laboratory at Ventura College.

with a military reserve unit can meet the eight-year obligation required under the Reserve Forces Act of 1955.

Upon completion of the four-year engineering curriculum, the student is eligible to apply for Officer Candidate School or a commission in a military reserve program.

At this stage in his career he may elect to remain on active military duty as an officer.

Commander Brannan writes—

"We are proud of our Student Engineering Development Program and are pleased to say that the Navy has adopted it as a standard Guide for similar programs at other commands. We are also proud to point out that our program is in operation. We have twenty boys in Ventura College, enrolled in lower division engineering work, and have phased-in five students at the University of California in Berkeley and Los Angeles in the upper-division engineering curriculum. We plan to enroll twenty additional students in Phase I in July, 1957, and ten more students in Phase II next fall."

SALES MANAGERS: You route this memo—

to your ad department and agency—reminding them to plan now to advertise in the 1958 I&A Handbook & Buyers' Guide

Industry's only instrument-control equipment buying directory, the Guide offers you . . .

- Entree to 23,000 buyers of instrument and automatic control equipment.
- A directory listing equipment, names and addresses of 3,000 manufacturers.
- Twenty-two years experience selling to OEM and end users.
- Year 'round contact with industry's big buyers.

Reserve your ad space now. Forms close August 15-31—write:

INSTRUMENTS PUBLISHING CO., INC.
845 Ridge Ave., Pittsburgh 12, Pa., FAirfax 1-0161

On February 1, 1957, the Assistant Secretary of Defense for Supply and Logistics formally announced the inauguration of an electronic data processing system to be utilized in processing a portion of the tremendous quantities of data involved in effective maintenance of the Federal Catalog System. This data processing system is installed in the Cataloging Division of the Office of the Assistant Secretary of Defense for Supply and Logistics, Washington, D. C.

Currently, this office is in the process of converting the data in its electric accounting machine card files to magnetic tape for use in the 705 System. Following this step, actual processing of daily transactions will be performed on the new system; however, concurrent processing operations will be continued with punched cards for a sufficient period of time to detect and solve any unforeseen problems. This is one of the latest developments in the streamlining process herein described.

Streamlining the Federal Supply Systems

FIG. 1. TRANSCEIVER SIMILAR to those used in the CONUS-DTSN. The machines, made by IBM, are used to exchange information on punched cards between all network points. (U.S. Army Photograph.)

U. S. ARMED FORCES have fought two World Wars and the Korean Campaign using an antiquated multiple "system" of supply. This system (or rather, lack of system) was a natural outgrowth of the historical cognizance system under which each Army Corps and each Navy Department maintained its own supply system. Prior to World War I this method worked smoothly. Increasing mechanization and automation of a large number of the implements of modern warfare have made necessary the supply of millions of components, many of which are used by all services and by several branches of each service.

Public Law 436

The military services and the Department of Defense have recognized the need for a single catalog system for many years. At the end of World War II, 27 different types of stock numbers were in use by the military activities. The same item frequently existed in two or more supply systems, identified by different names, different descriptions and different stock numbers. No wonder that the sale of an item as surplus by one service often occurred just before another service found that it must advertise for procurement bids on the same item!

The task of converting to a single catalog system would be prodigious and costly. A complicating requirement was that conversion must take place while the various service supply systems were actively supporting the Armies, Air Wings and Fleets. The new structure must be built and checked before the old systems could be abandoned.

Accordingly, at the request of the military services and after endorsements by the Executive Branch and by the Hoover Commission, Congress in 1952 passed Public Law 436 directing the Department of

Defense to develop, establish, and maintain a single item identification system for use within and between all bureaus, services, and commands. Since that time the cataloging organizations of the three military departments and that of the Office of Assistant Secretary of Defense (Supply and Logistics) have identified almost 4-million "thought-to-be different" items of supply in accordance with the uniform, or *Federal Catalog System*. Now over 20,000 approved item names have been authorized and cross-referenced to cover 34,000 names no longer authorized. With completion of the initial job of identifying existing military items in December 1956, The Federal Stock Catalog contained a total of 3,129,000 supply item identifications.

Conversion

The business of buying, stocking, and dispensing equipment and supplies for the Armed Forces is divided between many different managers in each service. For example, the Bureau of Ordnance buys ammunition boxes for the Navy, the Ordnance Corps buys for the Army, and the Gadsden Air Force Depot buys this item for the Air Force. Each of these managers must have all its needs supplied during the conversion period; each must complete necessary paperwork changes and physical changes.

Paperwork changes encompass the changing to Federal identification data such records as stock records cards, due-in cards, due-out cards, requirements records, procurement records, work order records, financial records, other related material accounting and reporting changes, also catalogs, handbooks, manuals and maintenance documents. The physical changes which are related to warehousing, are changes to stock locator records, bin tags, stock markers, item tags, stock remarking, and sometimes re-warehousing. Also personnel must be trained for the change-over to the Federal System. Because of the magnitude of the task, complete conversion from previously-used systems of cataloging and identification will proceed separately by managers, who are all scheduled to be converted by the end of 1958. After this time all supply transactions in the military systems will use the common language of Federal Stock item identifications.

The Common Language of Identification

The Federal Catalog System establishes for each item *repetitively procured and stocked* by any branch of the government:

(a) a *single name.*

(b) a *single identification,* either by a description of its essential characteristics or by reference to manufacturer's data numbers (Fig. 3).

(c) *one location* in a *System of Classification.* This system now comprises 75 groups, further broken down into 535 classes. Each item can appear under only one classification.

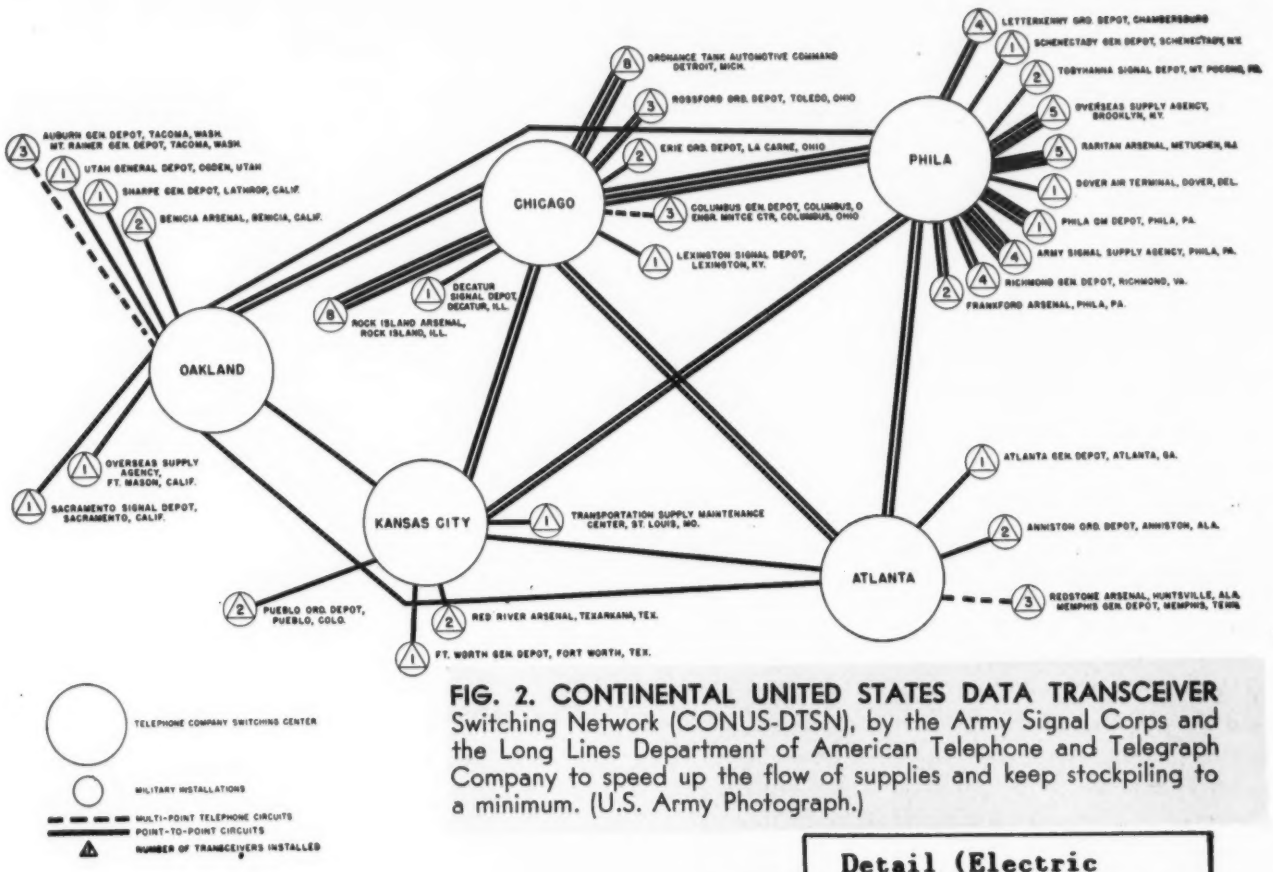

CHICAGO
PHILA
OAKLAND
KANSAS CITY
ATLANTA
ORDNANCE TANK AUTOMOTIVE COMMAND DETROIT, MICH.
ROSSFORD ORD. DEPOT, TOLEDO, OHIO
ERIE ORD. DEPOT, LA CARNE, OHIO
COLUMBUS GEN. DEPOT, COLUMBUS, O
ENGR. MNTCE CTR, COLUMBUS, OHIO
LEXINGTON SIGNAL DEPOT, LEXINGTON, KY.
DECATUR SIGNAL DEPOT, DECATUR, ILL.
ROCK ISLAND ARSENAL, ROCK ISLAND, ILL.
AUBURN GEN. DEPOT, TACOMA, WASH.
MT. RAINER GEN. DEPOT, TACOMA, WASH.
UTAH GENERAL DEPOT, OGDEN, UTAH
SHARPE GEN. DEPOT, LATHROP, CALIF.
BENICIA ARSENAL, BENICIA, CALIF.
OVERSEAS SUPPLY AGENCY, FT. MASON, CALIF.
SACRAMENTO SIGNAL DEPOT, SACRAMENTO, CALIF.
PUEBLO ORD. DEPOT, PUEBLO, COLO.
RED RIVER ARSENAL, TEXARKANA, TEX.
FT. WORTH GEN. DEPOT, FORT WORTH, TEX.
TRANSPORTATION SUPPLY MAINTENANCE CENTER, ST. LOUIS, MO.
LETTERKENNY ORD. DEPOT, CHAMBERSBURG
SCHENECTADY GEN. DEPOT, SCHENECTADY, N.Y.
TOBYHANNA SIGNAL DEPOT, MT. POCONO, PA.
OVERSEAS SUPPLY AGENCY, BROOKLYN, N.Y.
RARITAN ARSENAL, METUCHEN, N.J.
DOVER AIR TERMINAL, DOVER, DEL.
PHILA QM DEPOT, PHILA, PA.
ARMY SIGNAL SUPPLY AGENCY, PHILA, PA.
RICHMOND GEN. DEPOT, RICHMOND, VA.
FRANKFORD ARSENAL, PHILA, PA.
ATLANTA GEN. DEPOT, ATLANTA, GA.
ANNISTON ORD. DEPOT, ANNISTON, ALA.
REDSTONE ARSENAL, HUNTSVILLE, ALA.
MEMPHIS GEN. DEPOT, MEMPHIS, TENN.
TELEPHONE COMPANY SWITCHING CENTER
MILITARY INSTALLATIONS
MULTI-POINT TELEPHONE CIRCUITS
POINT-TO-POINT CIRCUITS
NUMBER OF TRANSCEIVERS INSTALLED

FIG. 2. CONTINENTAL UNITED STATES DATA TRANSCEIVER Switching Network (CONUS-DTSN), by the Army Signal Corps and the Long Lines Department of American Telephone and Telegraph Company to speed up the flow of supplies and keep stockpiling to a minimum. (U.S. Army Photograph.)

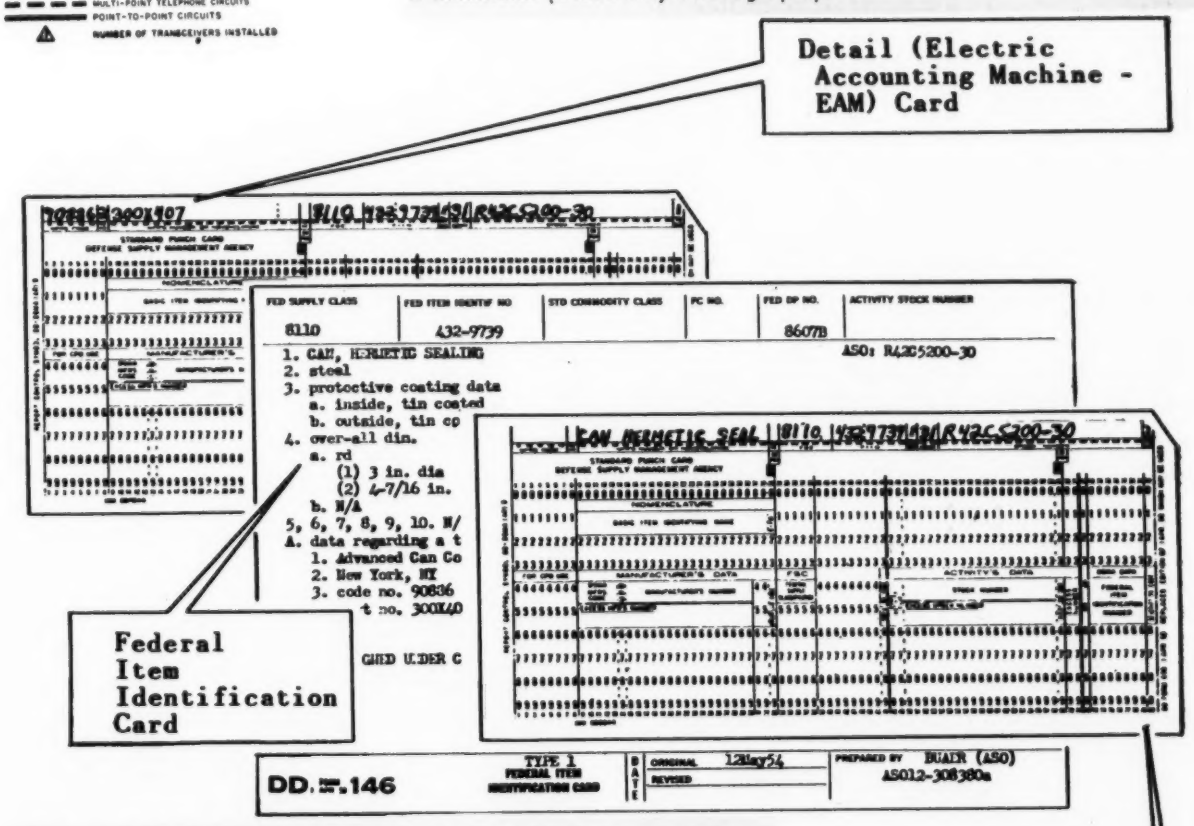


FIG. 3. THREE STANDARDIZED CARD FORMS are used by all military cataloging activities as the basic official record of all identification data. These are: (1) Federal Item Identification Card—contains minimum data to establish the essential characteristics of an item and differentiate it from every other item of supply. (2) Trailer Card—record of Federal Stock Number (FSN), approved item name, using activity and activity stock number. (3) Detail Card—record of all manufacturers' references related to and/or comprising the FSN—one reference for each Detail Card. (U.S. Navy Photograph.)

(d) *one stock number*. The first four digits are the Federal Supply Classification assigned to the items, such as the number 6710 representing the class of motion picture cameras. The next seven digits are sequentially assigned to only one item throughout the entire system. A complete Stock Number is thus composed of 11 digits. This Federal stock number applies only within the government supply systems and is designed for internal management. It does *not* replace or modify manufacturer's numbers.

The Standardization Program

One of the major benefits of the Federal Catalog is the Defense Standardization Program wherein a comprehensive review is made of all items in military supply, and, through standardization, these items are reduced to a minimum. Standardization is accomplished first through simplification or deletion of duplicates or near-duplicates and then through technical analysis and redesign.

The standardization program requires coordination between the various offices and managers which are interested in each class. For instance, primary responsibility in class 6675 (Drafting and Surveying Instruments) is assigned to the Corps of Engineers Department of the Army for preparation, but the Bureau of Yards and Docks, Department of the Navy, and the Middletown Air Material Area, Department of the Air Force, are designated as participating activities.

A few typical accomplishments already achieved under the standardization program are:

- Simplification applied to parts for Boeing Aircraft resulted in elimination of 3,689 items out of 4,193 items listed before simplification, leaving only 504 items. Annual savings due to storage, catalog maintenance, and record-keeping of eliminated items totaled $65,321.35.

- A savings of $465,000 on a 21,237 unit contract for shipping boxes, reusable, metal, was achieved as a result of design changes.

- Twenty-five styles of ceramic capacitors have been reduced to 3 as a result of a new standard specification. The reliability of the equipments in which these are used will be improved.

- Standardization of construction and related materials have resulted in a reduction of 57 line items with an approximate savings of $2,400,000 based on lowered inventory value and handling costs.

- A revised military standard for electrical and electronic reference designation provides a method for correlating the graphical symbols in diagrams with parts lists and maintenance instructions. The standard encourages a trend toward prefabrication of small electronic units, which promotes the use of standardized units, simplifies stocking of spares, and reduces maintenance problems.

Industry's Interest in the Federal Catalog System

The Department of Defense, in explaining the new system, has emphasized that contact with normal procurement channels of the Army, Navy, Air Force and Marine Corps are the same as before. These offices can explain any questions dealing with the Federal Catalog system. With items under procurement, the contractors can save time and achieve a better item identification if reference is made to Federal Standard #5, "Standard Guides for Preparation of Item Description by Government Suppliers." This is available at all General Services Administration Regional Offices.

Protection against the co-mingling of "will-fit" parts with quality parts is best provided if adequate technical data is made available by the contractor to enable the supply system manager to develop a precise quality item identification.

Electronic Processing of Supply Data

The simplification and systematizing of military logistics is making possible the more effective use of electronic data processing by the various inventory managers.

That venerable military bottleneck, the letter, also is being eliminated in military logistics systems. The Army has recently announced its new Data Transceiver Switching Network (Fig. 2) which speeds the flow of information data, and materials for Army Supply within the Continental United States, using data transceiver equipment made by IBM (Fig. 1). Information on punched cards is exchanged as desired between 33 military installations which are interconnected through five Bell Telephone System switching centers. This development extends the benefits of central electronic data processing to each outlying installation at minimum cost and eliminates manually-written order-forms and letters which have been used until now even between mechanized supply depots.

RADM. Thomas L. Becknell, Jr., Chief of the Bureau of Supplies and Accounts, U. S. Navy, recently stated, "in case of total war it takes too long to hire and train additional people after M-day (mobilization day). It takes too long to remodel office space, adjust procedures and to adapt to new conditions. It is too costly to over-staff in peacetime, and too risky to wait. The inherent speeds and capabilities of the automatic data processing systems offer great promise in terms of ability to expand our capacity rapidly in wartime without significant additions of plant or people.

"In other words, if and when "M-day" comes in this age of supersonic aircraft, guided missiles, and atomic-powered submarines and warships, Navy supply will be better able to keep pace with its customers' demands—thanks to its new 'electronic hardware.'

NADAR Scores Rocketry Meet

James Carey

Autonetics Div., North American Aviation, Inc.

NADAR, magnetic tape recorder-reproducer system, made its first operational appearance in the air-to-air rocketry phase of the recent USAF Weapons Meet at Vincent Air Force Base, Yuma, Ariz.

The compact 16.6-pound NADAR recorder unit rode aloft daily at altitudes ranging from about 1½ to 7 miles in forward compartments of four competing

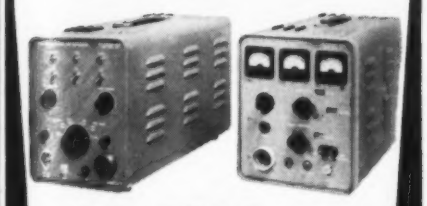
Enclosing tape reels and tape guides, the NADAR tape magazine is readied for installation on the hub drive mechanism by airman shortly before USAFE F-86D takes off for rocket firing.

teams' North American F-86D Sabre Jet interceptors. These teams represented the Eastern Air Defense Force, which emerged with top honors in the competition, Air Training Command, Far East Air Force and U. S. Air Forces In Europe. The other half of the NADAR system—a ground-based reproducer or playback unit—operated at the completion of these teams sorties or make-up flights in strategically-located operations huts along the flight line. Armament judges checked each NADAR-equipped aircraft's record tape before and after each sortie and witnessed the post-flight playback on the ground-based reproducer.

The Firing Run

The all-weather interceptors competing in the air-to-air rocketry meet closed on their aerial targets at about 1,000 feet per second. Pilots flew no slower than 430 miles per hour at the 9,000 foot pass, and

High Power* Oscillator



200-2500 mc/s

Here is a proven source of dependable, high-level r-f power that provides complete coverage from 200 to 2500 mc/s with just one simple band change. The model M1141 provides exceptional frequency stability and choice of self-contained sinusoidal or square wave modulation. These features, plus reliable, trouble-free operation, make the M1141 the best general purpose oscillator available anywhere. Look at the specifications listed below.

MAXSON MAKES IT

Specifications

Frequency Range:
200 to 2500 mc (in two bands, 200-1050 and 950-2500 mc/sec) Coverage to 3000 mc/s upon special request.

***Power Output:**
200- 400 mc—at least 40 WATTS
400-1050 mc—at least 25 WATTS
1000-2500 mc—at least 10 WATTS
(Power output variable by front panel control.)

Calibration Accuracy:
±1% or ±5 mc, whichever is greater

Resettability: < 0.1%

Output Impedance:
50 ohms (nominal)

Modulation:
1. External; 2. Internal square-wave, 400 & 1000 cps; 3. Internal sine-wave, 400 & 1000 cps; 4. CW

Power Requirement:
115V a-c, 50/60 cps, single-phase, 375-watt

Request "Maxson Instruments Catalog Sheet 101D"

MAXSON INSTRUMENTS
47-37 Austell Place
Long Island City 1, New York
Division of the W. L. Maxson Corporation

For more information circle **19** on inquiry card.

NADAR—*Cont.*

were permitted greater speeds up to their plane's capability. They fired rockets that travelled some 2,600 feet per second. Delivery of the rockets was made on "lead collision course", wherein approach and firing are from right angles to the target.

During the rocket runs, the F-86D's recorder was automatically placed in warm-up condition when the plane's firecontrol system was turned on. No pilot attention was required. Immediately upon establishing radar lock-on, the recorder's magnetic tape was automatically set in motion and began recording the attack display signals appearing on cockpit scope. These recorded signals represented artificial horizon (including pitch attitude), reference circle, time-to-go circle and steering dot as well as range-to-target and range rate information.

"Re-Flying" the Mission

Following completion of each mission, the recorder's tape magazine was removed from the plane, installed in the reproducer and the recorded signals were immediately displayed on a dual-beam, cathode ray oscilloscope. The tape didn't have to be removed, rethreaded or processed in any way to prepare for this review of the attack operation by judges, pilots and air crews. Tape has a number of advantages over the standard scope-camera method for recording radar indications still in use on intercept planes not equipped with NADAR.

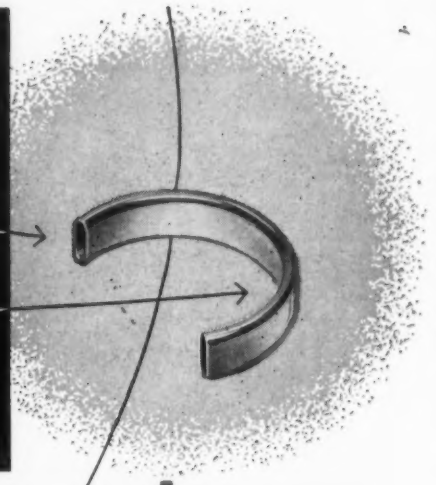
Minutes after returning from rocket firing run, the tape magazine assembly is installed in ground-based reproducer. Two USAFE pilots wait for immediate playback of record of attack run.

NADAR developed by North American's Autonetics Div. for aircrew evaluation and training, is now either installed or committed for installation in all current USAF all-weather interceptors.

The Navy's Bureau of Aeronautics has recently ordered one-half million dollars worth of NADAR V for installation in carrier and shore-based all-weather aircraft.

For more information circle **204** on inquiry card.

BOURNS new Bourdon tube pressure transducers



actual size

—a complete line designed for high range—with stainless steel or beryllium copper construction.

Bourns—designer and manufacturer of its own Bourdon tubes—now brings this proved component to absolute and differential pressure potentiometers. Three instrument models are provided for an extensive range of applications.

Model 704
Differential Pressure Potentiometer—*for corrosive fluids*
This unit has a stainless steel Bourdon tube and fittings, to withstand fuming nitric acid and other corrosive fluids. All mechanical joints are Heli-arc welded. The instrument will measure differential pressure between two high pressure sources.

Model 705
Absolute Pressure Potentiometer,
This absolute pressure potentiometer measures pressures in ranges of 0-100 to 0-1000 psia—extending the range of Bourns Aneroid Capsule instruments.

Model 706
Differential Pressure Potentiometer—*for non-corrosive fluids*
The Bourdon tube in this high range instrument is made of berryllium copper for use with non-corrosive fluids. With the low pressure port vented to the atmosphere, this unit can be used as a gage pressure instrument.

All models have a durable stainless steel case... compact configuration... excellent linearity, resolution and hysteresis. The rugged linkage system and Bourdon tube assembly provide excellent shock, vibration and acceleration characteristics. All models are now in quantity production. Write for new literature.

COPR. BL

BOURNS LABORATORIES
General Offices: 6135 Magnolia Avenue Riverside, California
Plants: Riverside, California—Ames, Iowa

For more information circle **20** on inquiry card.

The Analog Computer

Part II

Robert L. Yeager
Electronic Associates, Inc.

In the previous issue of this magazine, the components of a general-purpose analog computer were presented. In this issue the author shows how analog computers are programmed to accomplish simulation of electromechanical and aerodynamic mechanisms.

AS WAS shown in the previous issue of this magazine, the general-purpose analog computer comprises operational amplifiers, attenuators, multipliers—which can be connected via a patchboard to simulate systems of various types.

One common class of problems involves connecting integrators and attenuators in order to solve basic differential equations. A simple example of the use of integrators is shown in Fig. 14, which illustrates the familiar falling-body equation:

$$d^2x/dt^2 = -g \qquad (1)$$

Note that input to an integrator is always the negative differential of the output.

Closing the loop from the output to the input of a computer diagram effectively equates the output to the input, as shown in Fig. 15. This is the solution for the basic simple-harmonic-motion equation:

$$d^2x/dt^2 = kx \qquad (2)$$

Analysis of a Servomechanism

The analog computer has found wide application in analyzing servomechanisms. Let us assume that the servo being analyzed is the continuous closed-loop positioning system shown in Fig. 16. For purposes of clarification we have divided the servo into five sections as shown by the vertical dotted lines in the figure. The voltage θ_i represents the desired shaft position; the feedback voltage θ_o indicates actual shaft position. These two variables are compared in the differential, or comparator. The *error equation* representing the difference between the input and the output is:

$$e = \theta_i - \theta_o \qquad (3)$$

The voltage error thus generated is amplified by a gain factor, K, in the servo amplifier and applied to the field winding of the d-c servo motor as the driving voltage Ke.

We can write the equation describing the voltages around the field winding as follows:

$$Ke = R_F\, i_F + L di_F/dt \qquad (4)$$

where R_F = field winding resistance; i_F = field current; L = field winding inductance.

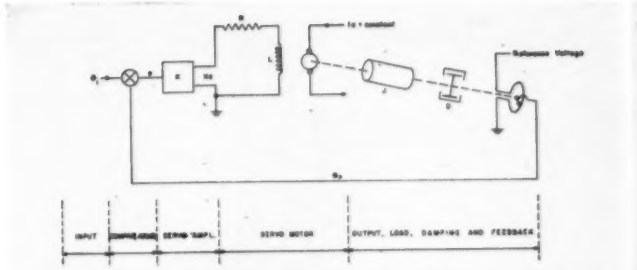


Fig. 16. Typical continuous closed-loop positioning system.

The equations describing the driving, damping, and load torques, and their relationships to each other, are:

$$T_M = K_T\, i_F \qquad (5)$$

where T_M = motor driving torque; K_T = gain factor; i_F = motor field current.

$$T_J = J\, d^2\theta_o/dt^2 \qquad (6)$$

where T_J = load torque; J = load moment of inertia.

$$T_D = d\theta_o/dt \qquad (7)$$

where T_D = torque due to viscous damping; D = damping coefficient.

The relationship between these torques is:

$$K_T\, i_F = J\, d^2\theta/dt^2 + D\, d\theta/dt \qquad (8)$$

Equations (3), (4) and (8) describe the dynamics of this system and will be used for programming the problem.

Scaling

At this point, *scaling* should be introduced into the programming. The scaling operation relates the actual variables to the voltages simulating these variables in the computer. For example, we must decide how many volts are going to equal a degree of rotation, a degree per second of velocity, etc. *Scaling relates the physical to the machine variables.*

Let us assume that this scaling operation has been properly accomplished and equations (3), (4) and (8) represent the exact machine equations to be programmed into the computer.

Programming the Computer

Equation (3) may be represented easily by one summing amplifier, as shown in Fig. 17.

In programming equation (4), it is customary to rewrite the equation as follows:

$$di_F/dt = (K/L)e - (R_F/L)\, i_F \qquad (9)$$

Equation (9) also can be written as:

$$i_F = (K/L)\int e dt - (R_F/L)\int i_F dt \qquad (9)$$

If we assume di_F/dt to be a known quantity, it may be integrated to give i_F. Having i_F and e—the latter available from equation (3)—it is necessary only to

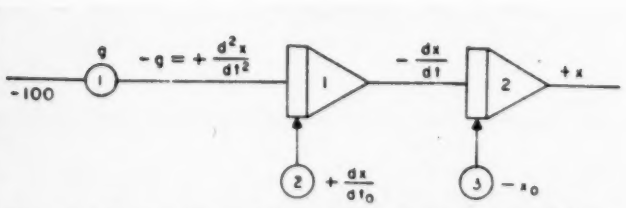


Fig 14. Computer solution for falling-body problem.

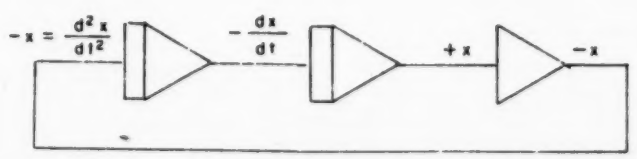


Fig. 15. Computer solution for spring problem.

Fig. 17. Computer diagram for error calculation.

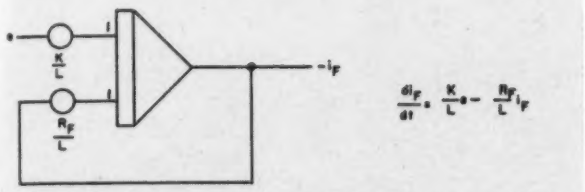


Fig. 18. Computer diagram for field current calculation.

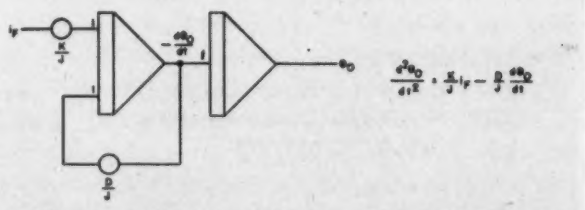


Fig. 19. Computer diagram for calculation of shaft position.

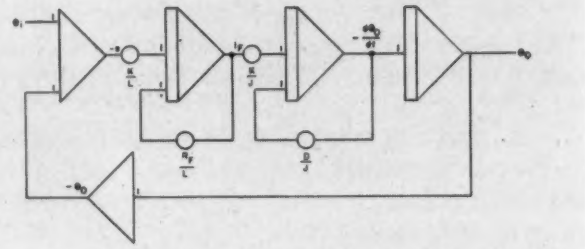


Fig. 20. Overall computer diagram.

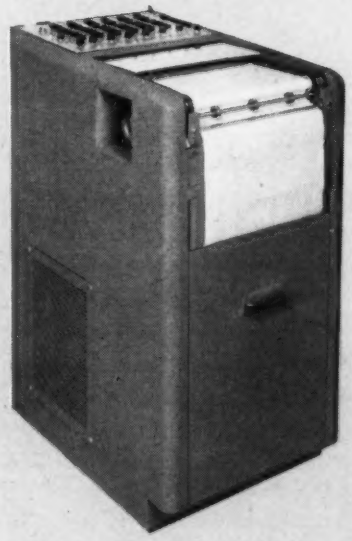


Fig. 21. Six-channel recorder used to display pertinent time-varying variables.

multiply each by its appropriate constant and sum them together in order to get di_F/dt; the quantity that was assumed to have been known. The computer wiring diagram for equation (9) is thus shown in Fig. 18.

The programming of equation (8) also involves rewriting the equation so as to solve for the highest order derivative—as was done with equation (4). Hence the equation and wiring diagram take the form shown in Fig. 19.

The over-all wiring diagram is obtained by putting the individual programs together and removing any redundant components. This final diagram is shown in Fig. 20.

The components shown in Fig. 20 are connected via the removable pre-patch panel discussed earlier in this series. Upon inserting the properly-patched panel and setting the coefficient attenuators, the problem is ready to be "run."

Many types of input disturbances can be introduced into the system for various values of load, damping and gain factors, the latter parameters being determined by simple potentiometer settings. All pertinent variables can be viewed on a time-base recorder of the type shown in Fig. 21. Thus, without the laborious mathematical calculations usually involved in the classical analysis of transient and frequency response, optimum values of all important parameters can be attained. Although we have treated a very basic problem, systems involving much greater degrees of complexity can be investigated, with correspondingly greater savings in engineering time and money.

Seat Ejection Study

An interesting and important analog study, typical of the dynamic problems being solved on analog computers, involves analysis of safe pilot ejection from disabled high-speed jet aircraft.* The basic problem is that of ejecting the pilot in such a manner as to assure his safe removal from the plane. An ejection that occurs too slowly would place him in a dangerous position with respect to the tail fin, while one that is too fast may exceed human thrust limits (about 20 G's for exceedingly short time duration).

A typical seat-ejection device (Fig. 22) consists of a ballistic charge enclosed in a telescoping tube which terminates in a small converging-diverging rocket motor. The tube rests below the seat in such a manner that when telescoping is effected by the explosive charge, the seat is forced away from the cockpit. At the time of full telescopic extension, the rocket motor begins to produce thrust and the entire assembly goes into a short period of stable, rocket-propelled flight, which assures complete removal of the pilot from the aircraft. Parameters, such as type of propellant, size of charge, friction between tubes, and mass of unit, must be considered.

*This problem was analyzed by the Talco Engineering Co., Hamden, Conn.

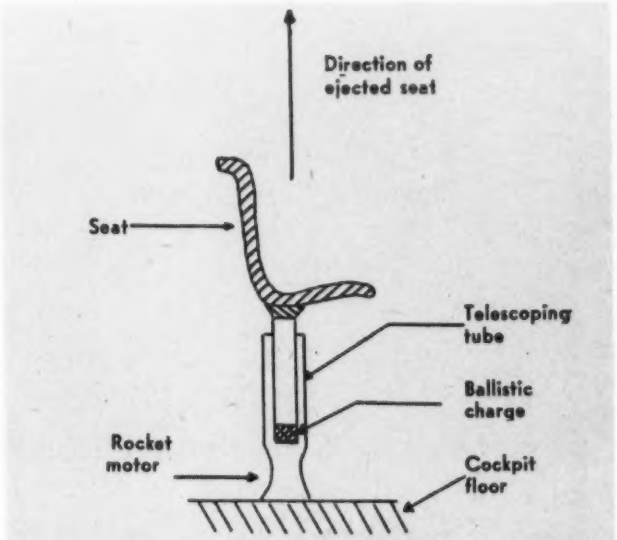


Fig. 22. Typical seat ejector.

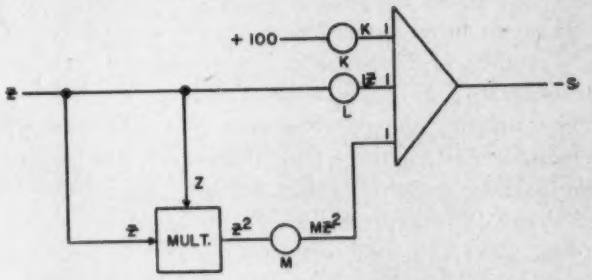


Fig. 23. Development of S as an algebraic polynomial of Z.

A ballistic problem of this nature can be represented by a total of 9 simultaneous differential and algebraic equations. All of these equations must be scaled and patched into the computer as previously illustrated. To show the entire program would be repetitious, but the wiring of two equations will be shown.

In order to determine ejection acceleration and velocity, a continuous computation of propellant burning surface must be made. The general equation that relates the propellant grain burning surface to the linear percent burned (Z) is as follows:

$$S = k + lZ = mZ^2 \qquad (10)$$

where Z is the fraction burned of available grain burning length, S is burning surface area and k, l and m are coefficients that change with grain geometry. Thus, the grain geometries that should be investigated are obtained by setting coefficient potentiometers producing k, l, and m. The wiring diagram for equation (10) is shown in Fig. 23.

A second equation that must be programmed is that which equates all longitudinal forces within the tube:

$$PA - F_f(x) - \alpha Mg = M\ddot{x} \qquad (11)$$

where P = pressure acting on end of tube; A = inside end area of tube; $F_f(x)$ = friction force as function of stroke; α = coefficient determining amount of "G" force acting "in line" with tube; g =

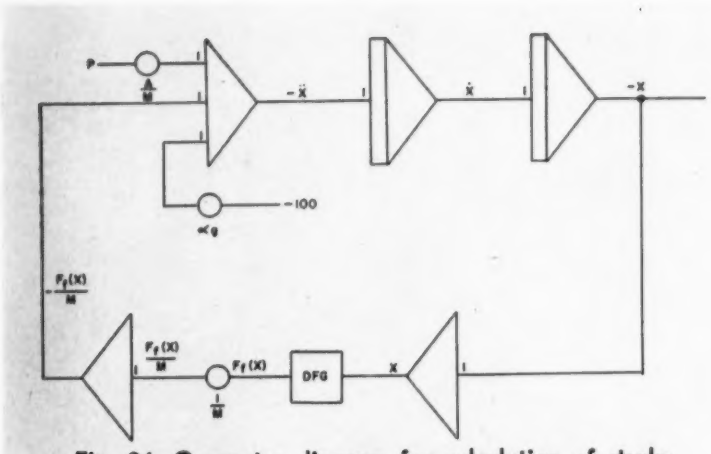


Fig. 24. Computer diagram for calculation of stroke.

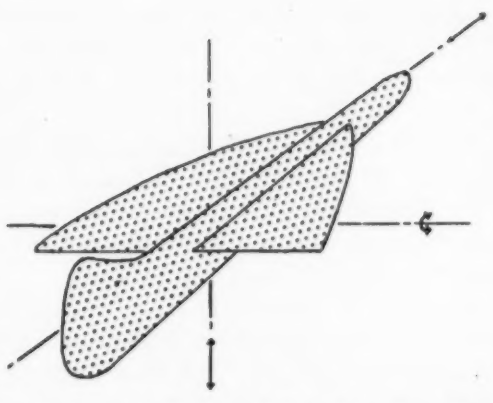


Fig. 25. Longitudinal mode of aircraft motion.

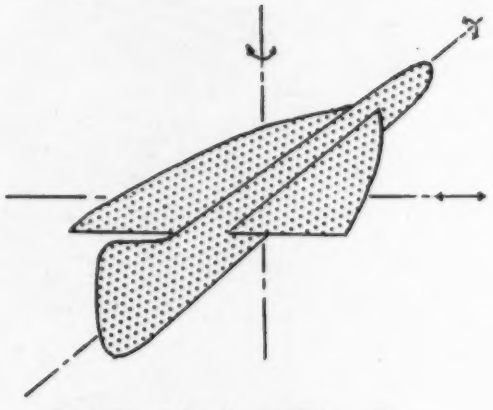


Fig. 26. Lateral mode of motion.

32 ft/sec²; $\ddot{x}$ = acceleration of ejected mass; M = mass of tube, seat and pilot.

Fig. 24 shows the program for this equation.

Thus we have shown the programming of two of the variables of the problem. The remaining variables are generated according to their respective equations, thus simulating the entire system. The time scale of the problem is lengthened by a factor of 100 because the real-time solution would normally take place in less than 0.25 second. The six-channel recorder shown in Fig. 21 can be used to record changes in pertinent variables as the different system parameters are investigated.

Thus, using analog simulation, the entire system is studied for different grain geometries, charge sizes, and tube and rocket structure under conditions of diverse aircraft maneuvering. Optimum parameters then are selected to meet requirements for safe operation.

Role of the Computer in Flight Simulation

Throughout the aircraft industry the analog computer is in general use for nearly all phases of modern aircraft design. After collecting basic wind tunnel data, the aerodynamicist constructs a set of differential equations which define the estimated dynamic response characteristics of the aircraft. Equations describing the control and stabilization systems are then determined. When the aerodynamic data are programmed with control equations, the entire aircraft may be electrically simulated. Thus, after tentative system requirements and airframe configuration have been established, an analog-computer study can be made of the complete system with all control and aerodynamic characteristics represented on the machine. During this analysis the simulated system is subjected to various parameter changes and transient and steady-state responses are studied. Design characteristics are then varied and the study continues until an optimum system is represented by the computer.

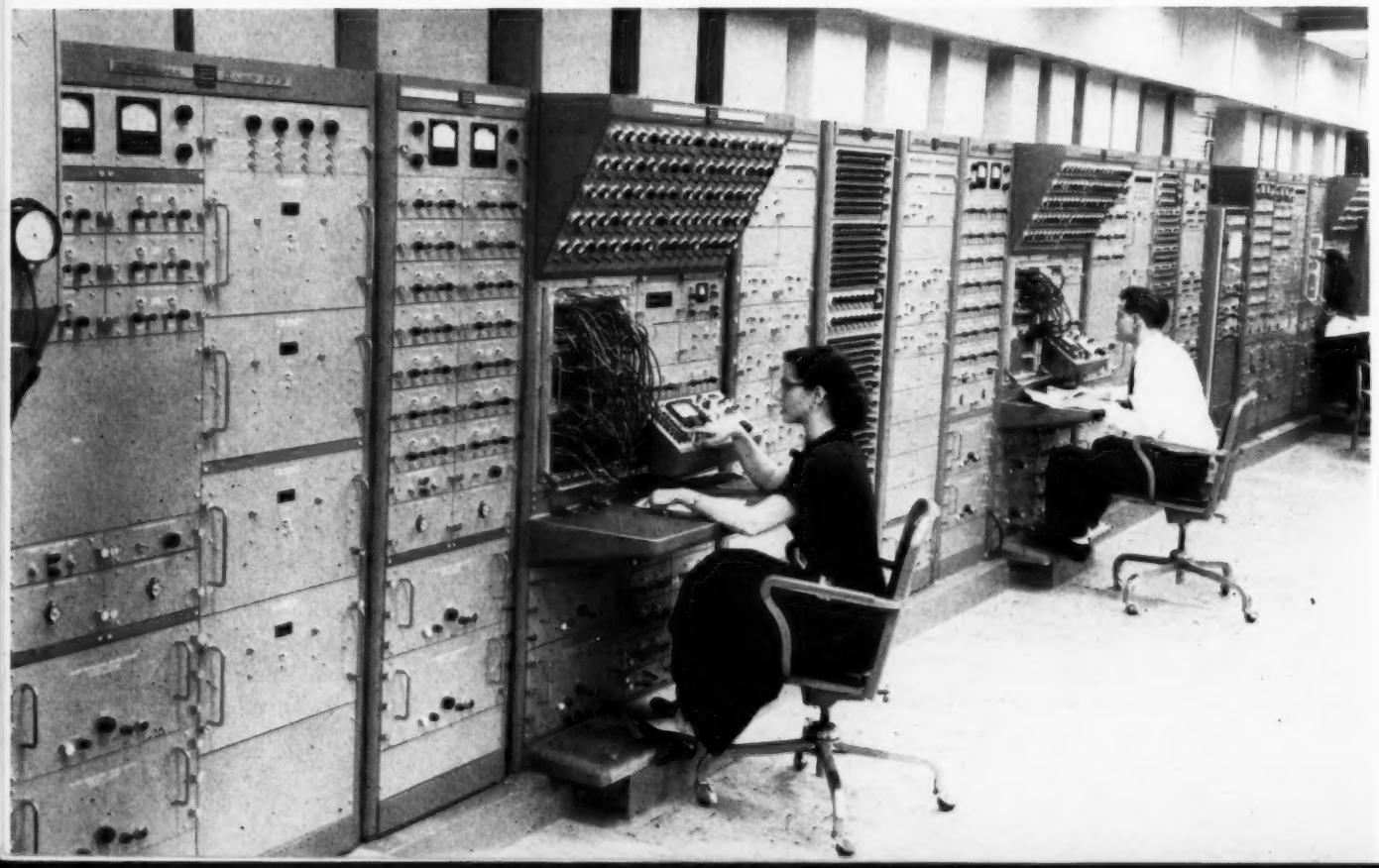
Aircraft simulation comprises three general phases:

1. *Study of Aircraft in the Longitudinal Mode*—This study generally includes programming the three equations describing the pitch moment, vertical translation, and longitudinal translation, as shown in Fig. 25. In this mode, the study is restricted to three degrees of freedom.

2. *Study of the Aircraft in the Lateral Mode.*—Three additional differential equations describe yaw moment, roll moment, and horizontal translation (Fig. 26).

3. *Six-Degree-of-Freedom Study.*—Even though the aircraft can be studied separately in the longitudinal and lateral modes of operation, and prove inherently stable in each, certain "cross coupling" terms, which serve to dynamically link these two modes, also must be introduced. Thus the final study usually comprises a total of six dynamic equations, which define the aircraft motion with "six degrees of freedom"—yaw, pitch, roll, horizontal translation, vertical translation, and velocity. Fig. 27 shows a typical six-degree-of-freedom simulator in operation at Waltham, Mass.

Fig. 27. Six-degree-of-freedom flight simulator in use at Radio Corporation of America, Waltham, Mass.



Flight Simulator

A computer that can solve three-dimensional aircraft problems on a 1:1 time scale is commonly termed a *flight simulator*. The 1:1 time-scale limitation is necessary because a flight simulator must usually operate in conjunction with actual control-system hardware, and autopilot, or even a pilot himself—all of which can operate only in a "real-time" situation. A typical flight simulation setup, employing a pilot cockpit and computer is shown diagrammatically in Fig. 28, while a photograph of an actual simulator is shown as Fig. 29.

In such a simulator, the control systems and airframe are represented electrically, and the pilot "flies" the computer. Aircraft responses are indicated to the pilot by the instrument panel while all important variables are also displayed for the engineer, using standard indicating and recording equipment.

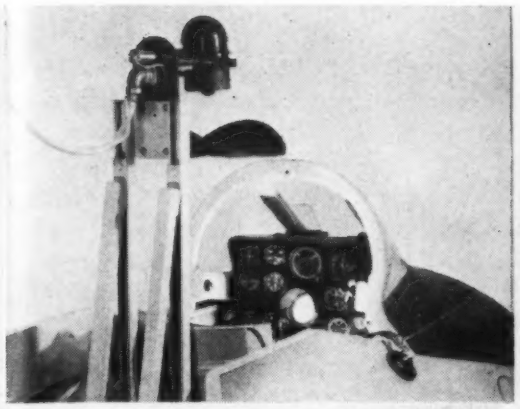


Fig. 28. Cockpit used by trained pilot to "fly" computer.

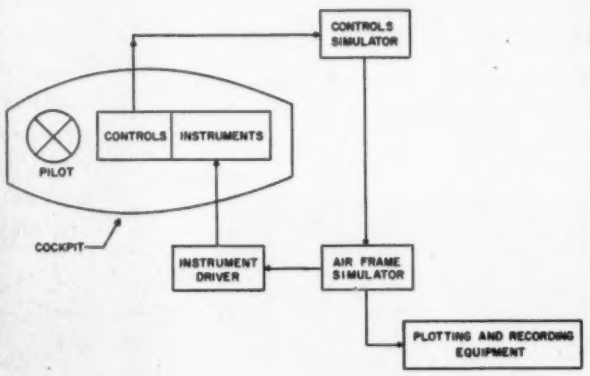


Fig. 29. Aircraft simulator block diagram.

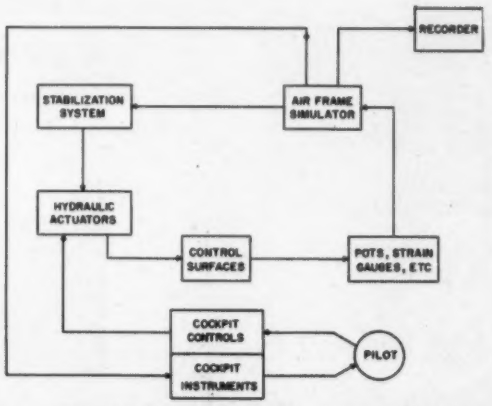


Fig. 30. Typical flight control simulator using actual controls hardware.

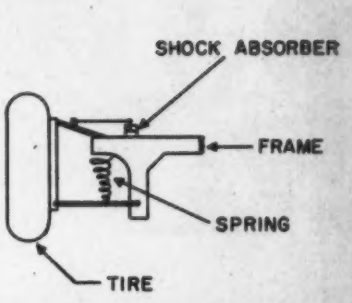


Fig. 31. Spring suspension of vehicle wheel.

Such a simulator may also be used to test the actual control systems designed for operation in a particular aircraft. The actual control system of the airplane, including cockpit display and controls, rudder, elevator and aileron actuators; hydraulic pumps and servos, etc., may be installed in a framework in the same relative positions in which they will be located in the aircraft.

Computer input signals in the form of d-c voltages representing positions of the ailerons, elevators and rudders are obtained from potentiometers, strain gages or torque bars attached to the control linkages. A simplified block diagram, representing such a setup, is shown in Fig. 30.

In addition to its use in aircraft design and systems testing, the flight simulator is a safe, rapid and reliable military training device. Instruction in instrument flying, aerial gunnery, and power-plant control can be expedited through its use.

Vehicle Suspension

The design of road vehicles also can be expedited by using analog simulation. A suspension system such as shown in Fig. 31 can be simulated using approximately 15 operational amplifiers and as many coefficient potentiometers. After the electrical analog of the system has been programmed into the computer, electrical disturbances representing typical road irregularities can be introduced. Under such conditions the simulator shows response of the dynamic system and the behavior of all elements can be studied. Various spring shapes and sizes, load masses, damping factors, etc. can be set into the system.

The simulator, with sufficient components, can be extended to study two, four, or more wheels simultaneously.

Suspension-system simulation has been applied successfully to the design of track-laying vehicles as well as wheeled vehicles. Ride behavior of a tank has been determined and interpreted so as to indicate the effect on personnel over long periods of time. The effect of hull motion on gun stabilization and internal component stresses also can be investigated by simulation.

Aircraft Stress Analysis

For purposes of stress analysis, aircraft structures can be represented by a system of algebraic finite difference equations. The solution of these equations is ordinarily complicated by three factors; (1) the large number of equations required in practical structures, (2) the desire to observe quickly the effect of changes in the individual parameters, and (3) the existence of local non-linearities. The use of electrical analog computations reduces these complications and permits large quantities of data to be processed in comparatively short periods of time.

Aircraft Dynamic Loads

Electrical analogs have been used for some time in the solution of the dynamic load problems of strut design, structural stress induced by landings, and flutter and vibration problems.

Nuclear Reactor Studies

The dynamics of the nuclear reactor can be reduced to their differential-equation form and programmed into the computer. Thus, operation of a complete reactor, including its associated controls, may be simulated. Analog facilities will be found in nearly all major reactor research laboratories.

Propellant Burning Rate Studies

Circuitry has been developed to facilitate computation of linear propellant grain burning rate on an analog computer. This burning rate is very significant in the interior ballistics design of propellant systems; i. e., shells, guns, rockets, etc. A knowledge of burning rate is required by the ordnance design engineer when computing chamber and barrel pressure, projectile velocity and other pertinent variables pertaining to a propellant burning system.

The foregoing applications have described only a few of the problems being solved by today's electronic general-purpose analog computer. The analog machine is being found in ever increasing numbers throughout the scientific world. Each day it is saving years of precious engineering time and tons of essential materials. The analog computer finds important use in the following additional fields:

Additional Analog Applications

Aircraft:

- Autopilot design
- Helicoptor blade design
- Missile and airplane control systems
- Stability studies
- Random gust analysis (using electronic gaussion noise generators)
- Catapult design
- Rocket motor studies
- Cockpit design
- Trajectory computations
- Turbojet and supercharger controllers
- Fire-control systems (air-to-air and anti-aircraft)
- Supersonic flow problems
- Jet engine simulation
- Control system design

Mechanical and Automotive:

- Gun stabilization control systems
- Hydraulic transmissions
- Vibration absorbers
- Shipboard fire control
- Crankshaft tensional vibrations
- Radar positioning systems,
- Heat transfer

Electrical:

- Study of linear and non-linear systems
- Transmission line analysis and protection
- Power distribution problems
- Electron optics
- Effects of noise in control systems

Miscellaneous:

- Process control simulation
- Operations research
- Interior and terminal ballistics
- Flood control
- Distillation column simulation
- Blast furnace studies
- Linear programming problems
- Beam deflection studies

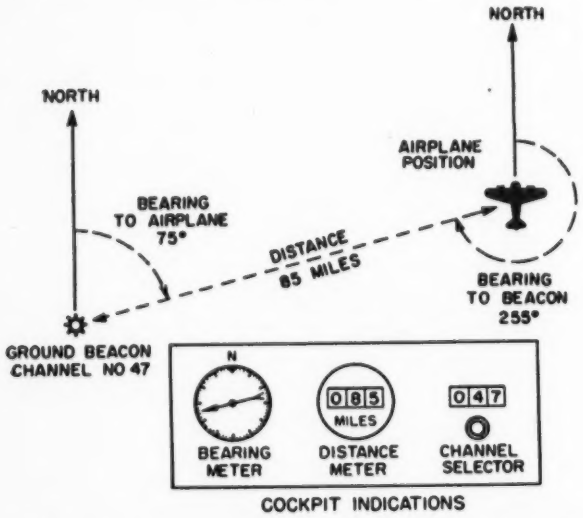
MA Lit Bits

Excerpts from important manufacturers' literature

TACAN Provides 120 Aircraft with R-Θ Data

TACAN Data Link offers military and civilian aviation a major tool for solving the ever-growing problem of congestion in the world's airways. It integrates FTL-developed TACAN (tactical air navigation) with an automatic, two-way, ground-air automatic reporting data link that eliminates the delay inherent in present "party-line" radiotelephone circuits.

TACAN, developed for the U. S. Navy and Air Force, is a radio air navigation system of the polar coordinate type which can provide 120 aircraft with instant continuous information on distance, in nautical miles, and bearing from a ground transmitter. A TACAN transmitter has 126 two-way operating channels available for assignment to various localities.



COCKPIT INDICATIONS

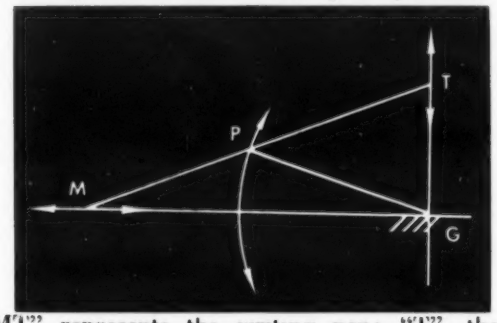
TACAN Automatic Reporting Data Link, a projection of the TACAN technique, operates on the same frequency and services the same number of planes.

Ground personnel using TACAN Data Link equipment can transmit instantaneous orders to aircraft for changes in distance, bearing, heading, altitude and speed. The new facility also provides a push-button arrangement which permits the ground station and aircraft to exchange printed messages. Push buttons are used by the pilot to acknowledge receipt of ground station commands and to initiate air-to-ground messages. (*From new* 4-*page Bulletin, Federal Telecommunication Labs.*, 500 *Washington Ave., Nutley* 10, *N. J.*)

For more information circle **301** on inquiry card.

recti/rite Eliminates Curvilinear Chart Error

The exclusive "recti/rite" system is an error-free linkage arrangement that satisfies basic trigonometry in changing curvilinear motion to true rectilinear motion. The system is based on the principle illustrated.

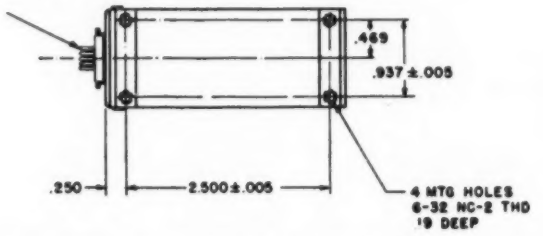


"MT" represents the writing pen; "T", the pen point; "PG", the swinging galvanometer metering arm; and "G", the fixed pivot of the meter movement. Then, if "PM", "PT", and "PG" are equal, "M", "T", and "G" would always be points on the circumference of a circle whose center is at pivot point "P". If, in addition, "M" is limited to fore-and-aft motion along line "MG", then "T" will always have linear motion perpendicular to line "MG". In the "recti/rite" system, PG/PM = PM/PT. (*From new* 6-*page Bulletin R*-501, *Texas Instruments Inc., Indust. Inst. Div.*, 3609 *Buffalo Speedway, Houston, Texas.*)

For more information circle **302** on inquiry card.

Gyros

Rate gyros, available in four basic sizes, provide a choice of drive motors and pickoffs to avoid any compromise in your system design. All Humphrey rate gyros include . . . unitized welded flexures, 3-axis high "G" balance, extra rugged wheel bearings, as well as floating piston constant action dry air dampers, and pressure-sealed cases.



Free gyros are available in two basic models . . . one is a manual push-button cage, electrical uncage; the other, fully remote electrical cage and uncage with indicating or inter-lock switches included. Precision potentiometer pickoffs provide accurate output over 358° on outer gimbal, and up to ±80° in inner gimbal. Precision balanced motors are made for 400 cycle 115 volt A.C. or 28 volt D.C. power input. (*From new* 24-*page Bulletin C*2457 "*Guidance and Control Instruments*" *including free and rate gyros, accelerometers, potentiometers, etc., Humphrey Inc.*, 2805 *Canon St., San Diego* 6, *Calif.*)

For more information circle **303** on inquiry card.

3C-PAC's Series M are Transistorized

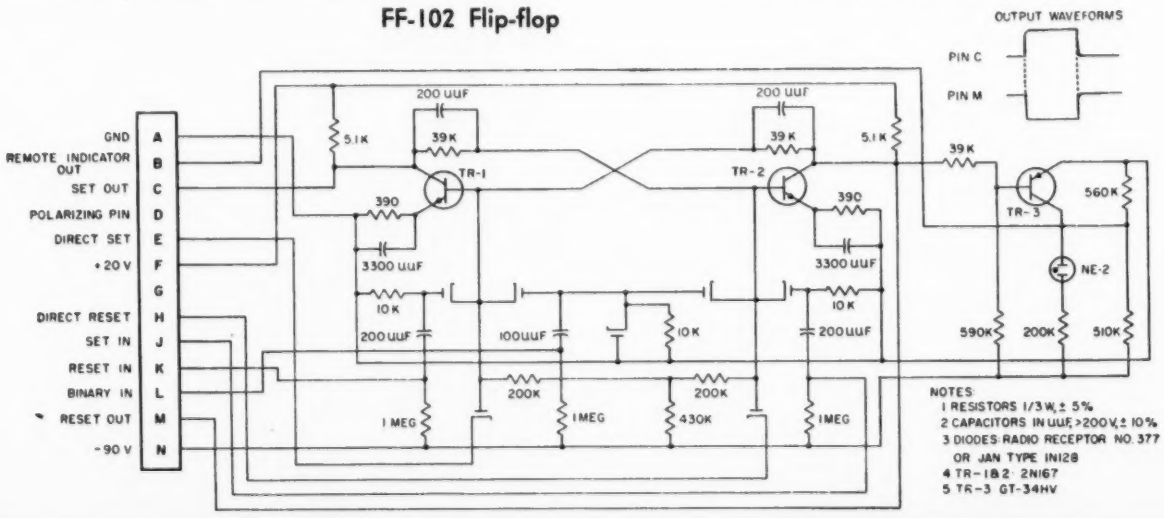
The new "Series M" 3C-PAC transistorized asynchronous digital plug-in printed circuit packages (include) D.C. cross-coupled (Eccles-Jordan) flip-flop, multi-leg germanium diode gates and buffers, emitter follower, pulse amplifier, one shot multivibrator, variable frequency blocking oscillator, inverter amplifier, square wave oscillator, etc.

This is a fully compatible line of digital building blocks. Compatibility implies ability to use these building blocks in a system merely by effecting the appropriate wiring directly between package connectors. Circuit components include transistors, crystal diodes, pulse transformers, and linear passive elements—no vacuum tubes.

The 3C-PAC model FF-102 Flip-flop employs an Eccles-Jordan D.C. cross-coupled circuit. The transistors are operated at cut-off or saturation, resulting in output swings of approximately 15 volts. (*From new* 20-*page Catalog M, Transistorized Modules, Computer Control Co., Inc.*, 92 *Broad St., Wellesley* 57, *Mass.*)

For more information circle **304** on inquiry card.

FF-102 Flip-flop

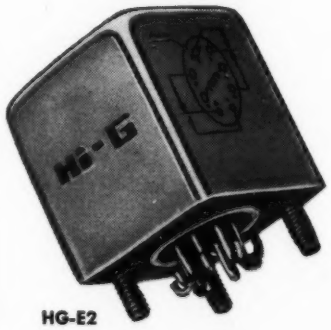


in every choice situation

As in many things, a little care goes a long way. For instance, selecting the right relay. Take the HG-2SM-R, for instance. Here's a new concept in sub-miniature relays by Hi-G. Only 1" and ½" long... diameter .635... operating frequencies from DC to 10,000 cycles per second... meets MIL-R-25018... with maximum operating temperature up to 140° C. Write today for complete details.

another outstanding

Hi-G relay



HG-E2

Sub-miniature... hermetically sealed... space saving, this HG-E2 relay measures 1" square by 31/32"... meets MIL-R-5757C. Designed for operating temperatures up to 125°C. with long-life characteristics at rated contact loads of 2 amps at 28 Vdc or 115 Vac. Coil resistance ranges of 50 to 10,000 ohms. Hook terminals or straight pins for plug-in and printed circuit applications are standard. Available in Form A, B, or C contact arrangement with maximum of two poles... for AC operation with internally mounted silicone rectifiers.

Today... find out more about the complete line of Hi-G sub-miniature relays.

Hi-G inc.

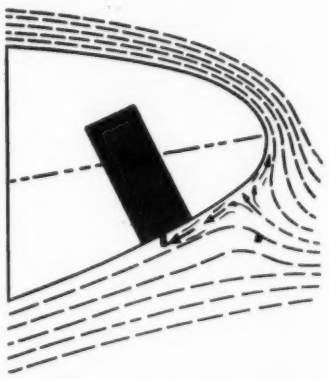
BRADLEY FIELD • WINDSOR LOCKS, CONN.

For more information circle **21** on inquiry card.

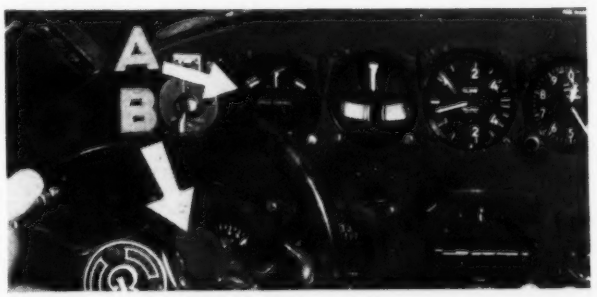
Taking IF out of LIFT

Lift ratio instrumentation is the science of measuring an aircraft's wing lift. The function of this speed control system is to give the pilot a continuous indication of the lift ratio of his aircraft to tell him the ratio of lift being used to the maximum lift available.

The instrumentation of lift ratio through speed control is basically a matter of determining the location and presence of the stagnation point at the wing's leading edge. This point at which the air separates to pass above and below the wing provides the index of wing lift. Channeling this intelligence to the cockpit is the function of the lift transducer. A small vane protruding from the leading edge of the underside of the wing senses through local airflow the relative location of the stagnation point. The lift transducer, by means of a variable reluctance transformer, transduces the position of the vane to an electric signal of exactly calibrated phase and amplitude which is measured by a bridge-type computer and transmitted to the speed control indicator (shown in D-18S Beechcraft). Here pointer position shows a normal approach. If aircraft is flown too slowly, needle moves to SLOW; if too fast, needle moves to FAST.



Small vane senses stagnant condition



A—Indicator; B—Column shaker

The system in operation is composed basically of four components: A lift transducer, a flap potentiometer, a lift computer and a speed control indicator. An optional control column shaker can be installed to shake the control column, simulating control buffeting, at or near stall speeds, thus serving as a stall warning for aircraft which do not normally exhibit this characteristic. (*From new 8-page Bulletin SF-10, Safe Flight Instrument Corp., 4 Water Street, White Plains, N. Y.*)

For more information circle **305** on inquiry card.

WANTED: A FIX

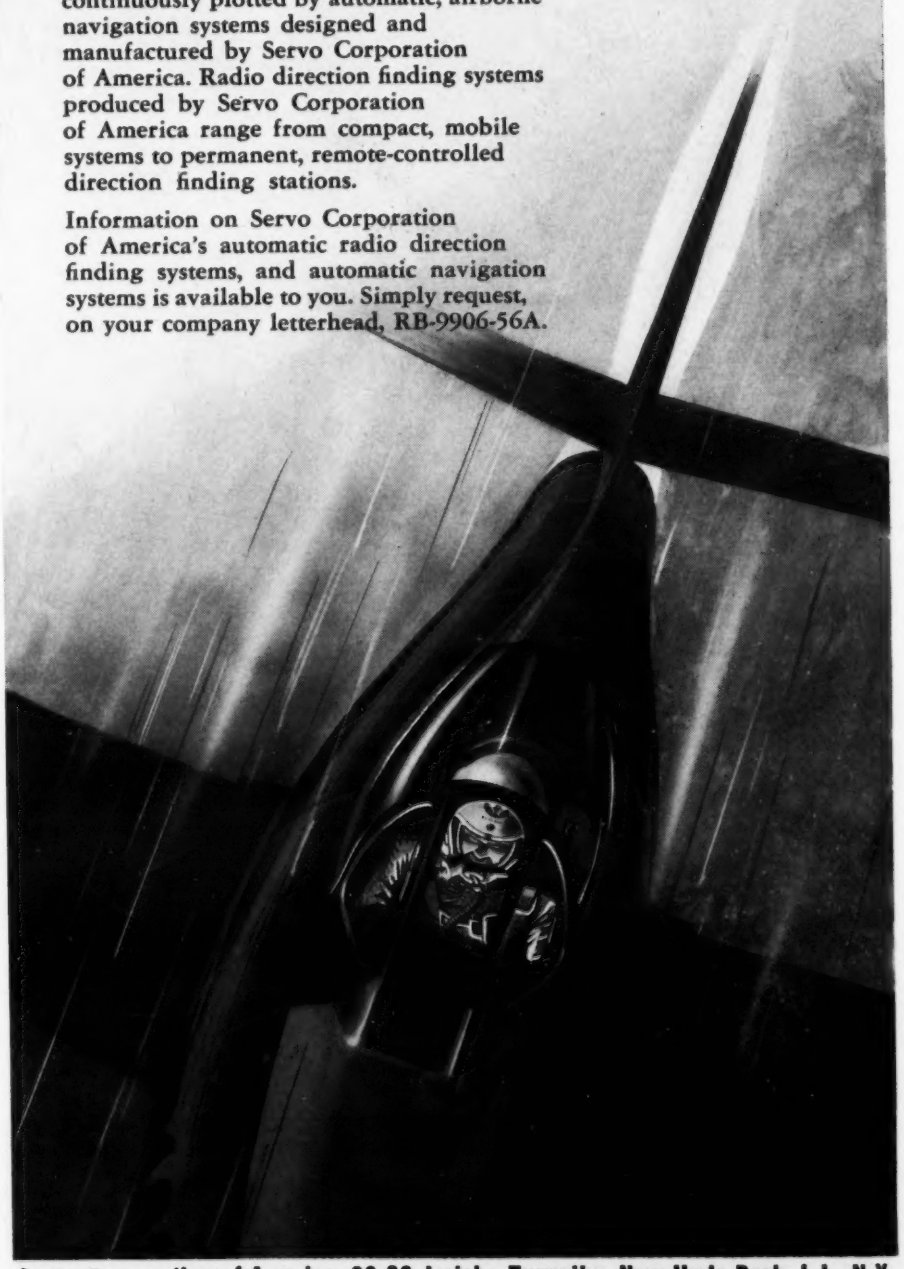
SERVO CORPORATION OF AMERICA

"Where am I?"
The success of the mission, the safety of both pilot and plane depend upon the correct answer to this question.

Supplying that answer instantaneously is the vital function of automatic ground-based radio direction finding and airborne navigation systems.

The newest multi-engined radar picket planes are guided with a course continuously plotted by automatic, airborne navigation systems designed and manufactured by Servo Corporation of America. Radio direction finding systems produced by Servo Corporation of America range from compact, mobile systems to permanent, remote-controlled direction finding stations.

Information on Servo Corporation of America's automatic radio direction finding systems, and automatic navigation systems is available to you. Simply request, on your company letterhead, RB-9906-56A.



Servo Corporation of America, 20-20 Jericho Turnpike, New Hyde Park, L.I., N.Y.

For more information circle **22** on inquiry card.

MA New Products

NEW AT IRE

NEW YORK, N. Y.—At the IRE Convention in New York, Mr. Roberts C. Sellers, (Left), Sales Manager for Avionics Division, Bell Aircraft Co., gives CDR C. O. Morrison, Editor of *MILITARY AUTOMATION* advance information on Bell Avionic's new

2.7 lb. "fist-size" precision gyro. The instrument features extremely short warm up time, insensitivity against wide temperature variations in storage, combined with a drift performance that is considerably better than any previously known precision gyroscope. The new gyro, heart of a new inertial navigational system for missiles and aircraft, was developed by Dr. Helmut Schlitt, now Manager of the Inertial Guidance Development Lab., Avionics Division, who was formerly with Redstone Arsenal and participated in development of the Peenemunde V-2 missile.

For more information circle **401** on inquiry card.

The following outstanding new products, not described in greater detail in this issue, were noted at the IRE show: Giant single crystals of silicon and germanium, for lens systems in Infra-red detectors—Texas Instruments Inc. (Circle No. **402**)

Magnetic memory planes for stacked construction—General Ceramics Corp. (Circle No. **403**)

Large Waveguides and components—I T E Circuit Breaker Co. (Circle No. **404**)

Klystrons in all sizes and traveling wave tubes—Varian Associates. (Circle No. **405**)

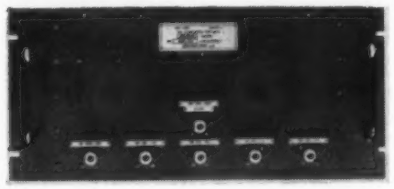
Build-it-yourself digital computer modules—Computer Control Inc. (Circle No. **406**)

Microwave TR, ATR, Pre-TR tubes and Microwave components—Bomac Laboratories, Inc. (Circle No. **407**)

Rugged & ready, sensitive, portable 3″ CRT oscilloscope—Dumont Laboratories (Circle No. **408**)

5-CHANNEL MULTIPLEXERS

New "Type RFM" RF multiplexers in frequency range of 50 to 4000 Mc are offered as fully engineered



units, with no further development work required except to meet unusual requirements. Each operates over an octave of frequency with outputs divided into five channels of equal bandwidths. Overlap of each channel eliminates dead spots in frequency spectrum covered. Cross-channel interference is minimized, and skirt selectivity greatly sharpened by use of four resonant circuits in each channel. Insertion loss of each resonant element is carefully limited to avoid deterioration of over-all system performance.—*Applied Research Inc., 163-07 Depot Road, Flushing, N. Y.*

For more information circle **409** on inquiry card.

AIRCRAFT SIGNAL SYSTEM

New "Dualex Digital Selective Calling Receiver" relieves pilots of the task of continuously monitoring a

radio channel: it performs the same function as a telephone bell and "Digital Selective Calling Transmitter" functions as the dial in the telephone system. By setting the call number of a particular aircraft on 5-dial transmitter, sender can alert only the one aircraft by flashing a light in its cockpit. Pilot then turns on his radio receiver to hear message. With 5-dial transmitter, any one of 100,000 (10^5) different planes can be called.—*Bell & Gossett Co., Dualex Div., Morton Grove, Ill.*

For more information circle **410** on inquiry card.

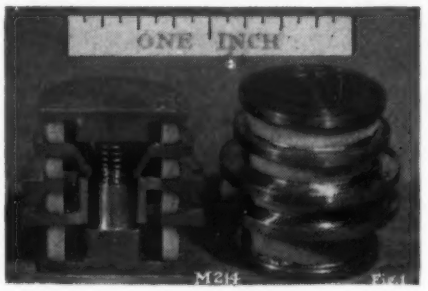
BEAM POWER TETRODE

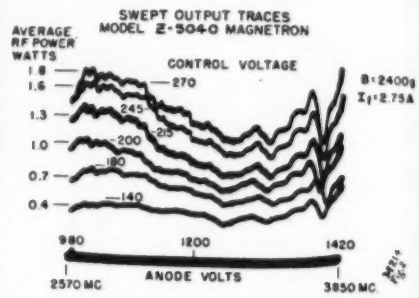
New "Type 6146," for use either as an RF power amplifier and oscillator or as an AF power amplifier and modulator, in both mobile and fixed equipment, features high power sensitivity and high efficiency. Plate dissipation 20w under CCS conditions and 25w under ICAS conditions. Maximum ratings apply up to 60 Mc, reduced ratings up to 175 Mc. A single "6146" has a maximum output of 52w as a Class C amplifier; two in a class AB_1 push-pull amplifier will deliver 82w of audio power; 90w of audio are available with Class AB_2 operation.—*Tube Division, Amperex Electronic Corp., 230 Duffy Ave., Hicksville, L. I., N. Y.*

For more information circle **412** on inquiry card.

VOLTAGE-TUNABLE MAGNETRON

New "Model Z-5040" C-W S-band voltage-tunable magnetron has average output power of 0.5 watt when connected in a tapered waveguide section for broadband operation between 2.5 and 4.0 kMc, or up to 5 watts in a tuned parallel circuit for 100-Mc bandwidth operation. Available now for experimental purposes, suggested ultimate uses include: altimeter service as a swept oscillator, output source for signal generator relay system component, relay system component in microwave communication, reflectometer types of signal generators, local oscillator in monitor and search radars, and, in combination with traveling-wave-tube amplifier, as a rapidly-tunable high-power generator. Less than ⅝" long, new tube requires a relatively light magnet (2.5 to 3 lb) and a microwave circuit designed to suit the particular application. Typical output curves show average r-f power versus anode volts/frequency. To avoid excessive temperatures, maker recommends use of a thermoscopic paint.* Operating characteristics of wide-band operation in





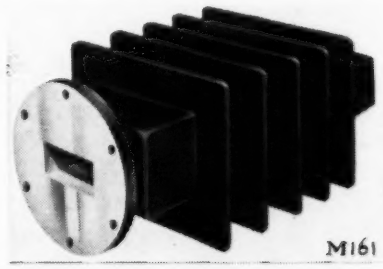
a tapered wave-guide section: Center anode voltage, 1300; magnetic field, 2500 gauss; dc filament current, 2.8 amp; dc filament voltage, 3; anode current, 15 ma; control electrode potential, +500 v; modulation voltage, from 1050 at 2500 Mc to 1550 at 4000 Mc; variation in 0.5-w average power output over this frequency range is less than 1 db.—*Tube Department, General Electric Co., Syracuse, N. Y.*

**Available from Tempil Corp., 132 22nd St., New York 11, N. Y.*

For more information circle **411** on inquiry card.

DUMMY LOADS

New "4063 VHP Series" of dummy loads has been granted JAN nomenclature and selected as the sole rec-

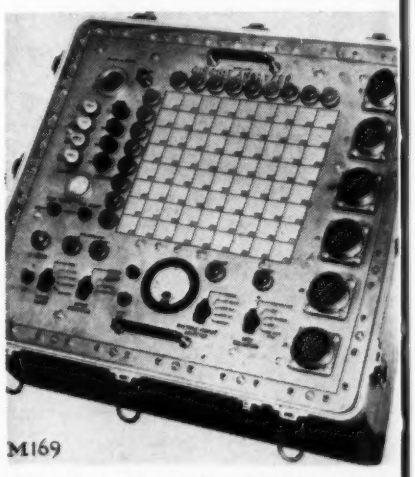


ommended component of this type.—*Bogart Mfg. Corp., Dept. EL, 315 Siegel St., Brooklyn 6, N. Y.*

For more information circle **413** on inquiry card.

UNIVERSAL AUTOMATIC CIRCUIT ANALYZER

New "Model 144NX" is an adaptation of "Model 200," repackaged in a light-weight water-tight fibre glass

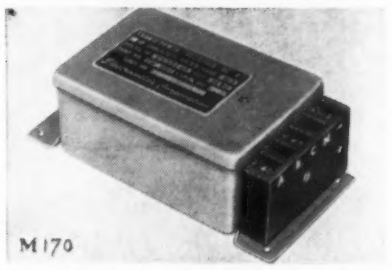


case to withstand rugged military use; is completely waterproof, shockproof and vibration-resistant. It automatically tests up to 144 circuits "in seconds." Simplicity of operation practically eliminates human error. "Model 144NX" can never become obsolete: never needs modification from one application to another.—*Dit-Mco, Inc., 911 Broadway, Kansas City 5, Mo.*

For more information circle **414** on inquiry card.

AIRCRAFT SILICON DIODE TRANSFORMER-RECTIFIER

New "Model CW-1001" tubeless transformer-rectifier facilitates use of dc equipment in aircraft with ac

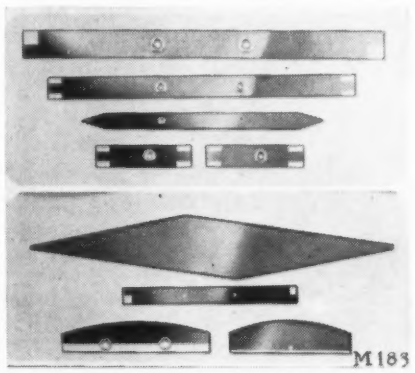


supply; delivers 50 amp at 27.5 vdc with an input of 115/200 3-phase wye 400 cps. Silicon power diodes are used in unit, with 25% of weight and 15% of volume of selenium type units.—*Electrosolids Corp., 7436 Varna St., North Hollywood, Calif.*

For more information circle **415** on inquiry card.

ATTENUATOR PLATES

New U S Gov-approved Metallized Glass Attenuator Plates with Metallized Eyelets meet MIL-A-11052A;



are available in six specific sizes for use with waveguides RG-48 /U, RG-49/U, RG-50/U, RG-51/U, RG-91/U. Metallized resistance elements, made by vacuum-evaporating pure metals to a glass base, are highly stable, unaffected by humidity, controllable as to resistance, and are reproducible. Their noise level is barely measurable and their temperature coefficient of resistance is about 75 ppm/C°.—*Metavac, Inc., 45-68 162nd St., Flushing 58, N. Y.*

For more information circle **416** on inquiry card.

GYRO FOR STABILIZATION, &c

Newly improved "Model U-105-H1G5" single degree of freedom gyro weighs 3 lb; is a hermetically-sealed

integrated unit featuring low drift rate, low harmonics, low quadrature and low noise level. Dynamically balanced gyroscopic element minimizes spin axis distortion and improved gimbal design minimizes nutation. High-strength solder joints are stable at elevated temperatures.—*Uniconn, Inc., Waterbury, Conn.*

For more information circle **417** on inquiry card.

OSCILLOSCOPE DOLLY

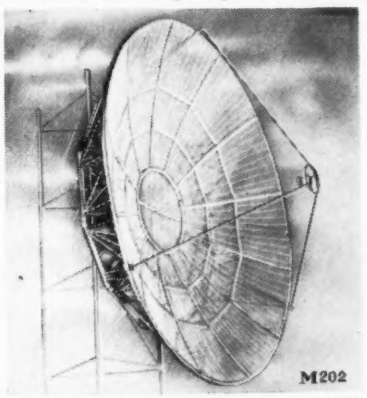
New improved "Scope Dolly" has three power outlets and one power input; damage-proof storage for spare

preamplifiers; roomy storage pan for tools, manuals, etc. Steel, baked-enamel finish (knocked-down shipping, 45 lb). Accommodates any popular-type lab 'scope by simple bracket relocations.—*PRB Mfg. Co., H and Luzerne Sts., Philadelphia 24, Pa.*

For more information circle **418** on inquiry card.

PARABOLIC REFLECTOR

New 32-ft parabolic reflector is said to feature great strength, ease of erection and rigidity in mounting;

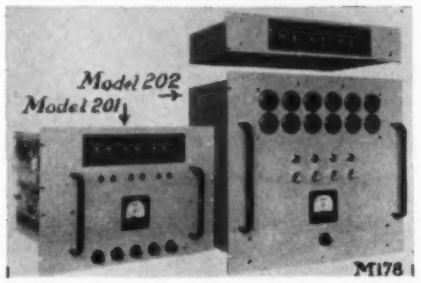


represents a "new design philosophy": is built around a 12-sided polygon torsion frame, 3-ft thick by 22 ft dia. Dead loads as well as added wind load of antenna are directly transmitted to this polygon frame. Each of the twelve outer sections is easily transportable for assembly at point of installation. Assembly is simple and fast. "D-322" is designed to be driven in a frequency range of 100 to 2400 Mc. Focal length is 13½ ft and the reflector gain with a focused antenna at 2400 Mc is about 44 db per antenna and 88 db per system.—*Technical Appliance Corp., Sherburne, N. Y.*

For more information circle **419** on inquiry card.

RAPID ACCESS DEVICES

New "Model 201 Digital Timing Generator" and new "Model 202 Magnetic Tape Search Unit" provide auto-

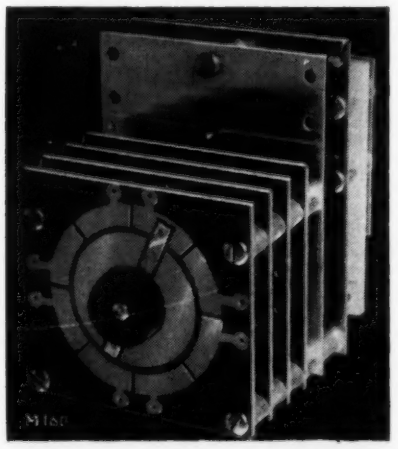


matic high-speed access to selected data in Ampex recorders and similar multichannel magnetic tape instrumentation systems. "Model 201" generates numerically-coded timing signals which are recorded on the mag tape throughout the data-recording periods; also visually displays exact time in hr, min and sec as illuminated digits. "Model 202" operates during data reduction periods. On basis of time indices recorded on the tape by "Model 201," it automatically locates and selects for controlled playback the tape data included between a "sequence start time" and a "sequence end time" specified by panel dial settings. Time index is visually displayed as illuminated digits on a small separate panel (which can be remotely located). Features include tape speeds of 60, 30, 15, 7-½, 3-¾ or 1⅞ ips for recording, plus high-speed search rate for playback; and forward or reverse directions.—*Dept. DR, Hycon Eastern, Inc., 75 Cambridge Parkway, Cambridge 42, Mass.*

For more information circle **420** on inquiry card.

SUBMINIATURE TIMER

New "Model AGC Sequence Timer," developed for balloon instrumentation, has features that should inter-



est designers in many fields: light weight (3½ to 4½ oz), small size, (2¼" high), accuracy, accommodation of 2 to 32 circuits (standard) and special time sequences. Timing circuits are of commutator type and are isolated from the motor assembly.—*Brailsford & Co., Inc., 670 Milton Road, Rye, N. Y.*

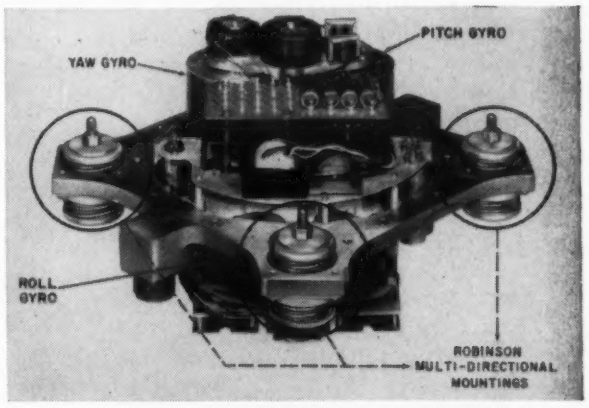
For more information circle **421** on inquiry card.

Satellite Guidance

UNLIKE systems that require radio or radar tracking so that commands can be issued to a vehicle's flight control system, the Vanguard guidance reference system is entirely rocket-borne. Its job will be to keep the finless rocket from swerving off course and to "tip" the rocket's trajectory gradually so that it enters a globe-circling course some 300 miles above earth.

Heart of the controls system are three highly-accurate electronic gyroscopes, HIG (hermetic integrating), that will be calibrated to a "memorized" heading reference in the three axis or directions of flight—roll, pitch and yaw. They require bearings alike to within 10 millionths of an inch. (If you took a hair and split it into 400 parts, one part would be 10 millionths of an inch wide.)

An HIG can measure the rate at which a glacier melts, or motion 3,000 times slower than the hour hand on a watch. Its response is so fast that the minute movements of a second hand are snail-like by comparison.



Vanguard Guide Reference Table

If the rocket rotates incorrectly—because of sloshing fuel, engine irregularity, etc., even an infinitesimal part of a degree—the gyro motors will respond by rotating the gimbal on its jeweled bearings. This movement is sensed by the gyro signal pickoff and sent out as an electrical signal from the gyro through the autopilot amplifier to the error-correcting servo system. The HIG-6 gyro used in the Vanguard rocket application is specially made for the system, because—unlike true inertial-type guidance systems—the Vanguard system is "strapped down" to the rocket. Thus the gyro was too sensitive for the application—like an automobile steering wheel with insufficient "play"—and the gyroscopic engineers had to cut the size of the gyro wheel.

HIG gyros are in production at Minneapolis-Honeywell's Aeronautical Division. About 19,000 of these ultra-precise HIGs have been produced for various applications.

For more information on "HIG" circle **205** on inquiry card.
For more information on "Robinson Mountings" circle **206** on inquiry card.

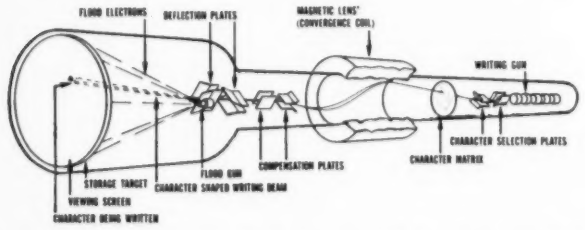
New Displays Make Time Stand Still

The CR tube has become as standard a tool for electronic measurement as the voltmeter. However, anyone who has ever used a conventional oscilloscope . . . has at one time or another voiced one desire. If it were only possible to retain the image on the tube face long enough to study it.

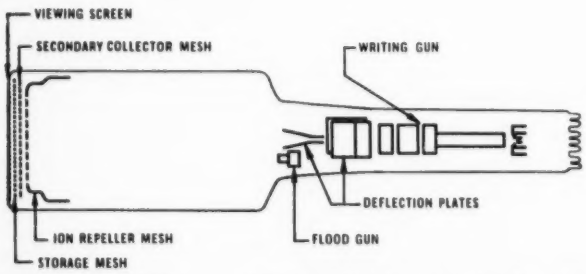
In the new family of Hughes storage tubes—*Typotron*, *Memotron* and *Tonotron*—this wish becomes a reality. To the traditional cathode-ray tube have been added two vital elements: First, a flood gun and, second, a storage target or dielectric mesh. These innovations make possible presentations of a display of infinite or extended persistence through electrostatic storage built into the tube.

TONOTRON . . . to present "A" scan, "B" scan, weather radar, and plan-position-indicator information . . . also for viewing "frozen action" in half-tone image form . . . closed-circuit TV, slow scan narrow-band TV, ship-to-shore map or chart process monitoring, ground-to-air map or traffic-pattern transmissions.

TYPOTRON . . . for high-speed read-out (25,000 characters/second) from digital computers . . . display of computed radar-tracking information . . . monitoring analog-to-digital conversion equipment. Ideal



for visual reference; eliminates need for intermediate storage facilities to match slow, mechanical read-out devices to high-speed electronic computing units. Data can be presented in words, numbers or symbols—63 characters are available.

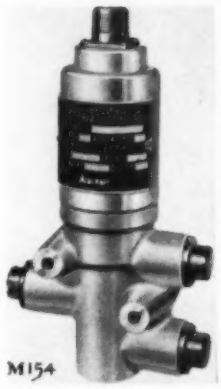


MEMOTRON . . . for the display of single transients, or superimposing transients for direct analysis and comparison . . . plotting a family of curves . . . viewing transients from shock or vibration tests and ballistics or missile tests . . . monitoring phase relationships . . . electrocardiographic and vectorcardiographic diagnosis . . . presentation of tube or transistor characteristics. (*From new 8-page Brochure* 90-34, *Hughes Products, Electron Tubes, International Airport Station, Los Angeles* 45, *Calif.*)

For more information circle **306** on inquiry card.

New Products–*Cont.*

3-WAY SELECTOR VALVES

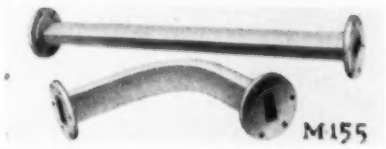


New line of 3-way solenoid-operated selector valves for 3000 psi service handles 85% higher flows than conventional models. Two size ranges: ¼" & ⅜" tubing, and ⅜" & ½" tubing; permit flow in any direction and feature a compact porting configuration. Of interest to aircraft engineers: flow can be reversed between any two open ports without disturbing flow or operating characteristics of valves. This is accomplished by a fully balanced inverse poppet.—*Aircraft Products Co., 300 Church Rd., Bridgeport, Pa.*

For more information circle **422** on inquiry card.

MICROWAVE COMPONENTS

New precision microwave components are made from oxygen-free high-conductivity copper, said to be

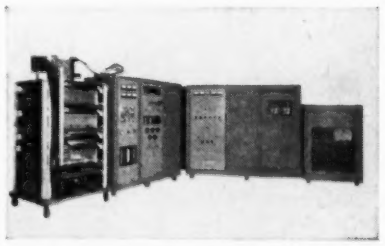


"the best that can be used to minimize losses in long transmission lines"; are available in straight sections, bends and pressure adapters in WR-137 waveguide size. Used in combination with standard flexible waveguide components and windows, they readily lend themselves to installation for microwave relay systems operating in 6000-Mc region.—*Airtron, Inc., Dept. B, 1103 W. Elizabeth Ave., Linden, N. J.*

For more information circle **423** on inquiry card.

RADAR TRANSMITTER

New "Model PC 49" utilizes an Eimac "X-590" klystron tunable from 225 to 400 Mc and produces up to 60

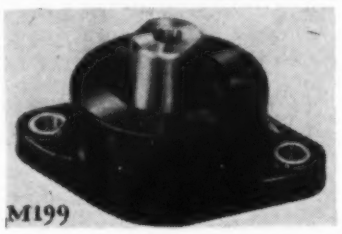


kw of peak power and 20 kw of average power. Maximum duty cycle 33% with pulse lengths continuously variable from 50 to 20,000 usec at rep rates up to 1500 pps.—*Levinthal Electronic Products, Inc., 726 Stanford Industrial Park, Pala Alto, Calif.*

For more information circle **424** on inquiry card.

ALL-METAL MOUNTING

New "Model W218 Met-L-Flex" shipboard mountings for delicate equipment aboard surface ships and

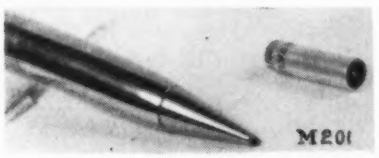


submarines meets shock and vibration requirements of MIL-S-901, MIL-M-17185, and high-impact shock tests of MIL-T-17113; has a low natural frequency (5-12 cps) whence equipment isolation from high-impact shocks of local explosions, gunfire, and steady-state engine and propeller vibrations. Isolation of vibration is 80% at 40 cps and improves at higher frequencies. Available in three load ranges: 20-30, 30-40 and 40-50 lb.—*Robinson Aviation, Inc., Teterboro, N. J.*

For more information circle **425** on inquiry card.

VIDEO DETECTOR CRYSTAL

New "IN630" microwave video detector crystal for military applications operates at temperatures up



to 150°C over a wide frequency range (1000-12,400 Mc); is a small tripolar crystal which performs with high sensitivity and reliability at temperatures said to be "50% greater" than can be withstood by conventional coaxial crystals performing similar functions.—*Sylvania Electric Products Inc., 1740 Broadway, New York 19, N. Y.*

For more information circle **426** on inquiry card.

FERRITE CORE CHOKES

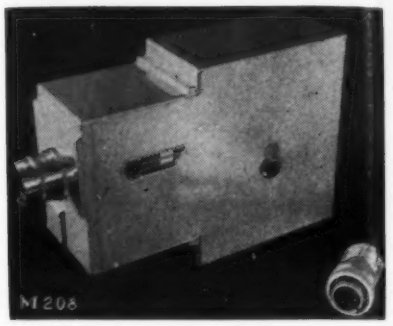
New complete set of "Blue Chip" high-*Q* ferrite coils comprises 14 inductances from 150 microhenries to 1

millihenry in MIL-spec inductance values. Units are for use in networks and filters at frequencies from 50 to 1500 kc; can be used also as resonant elements in IF and RF circuits; are impregnated with fungus-proof varnish per MIL-VI73A; are temperature stable with a maximum drift of less than 600 ppm/C°.—*National Company, 61 Sherman St., Malden 48, Mass.*

For more information circle **427** on inquiry card.

PHOTOGRAPHIC RECORDER

New 16mm "DVR-42" precision pulse-operated photographic recorder for time lapse photography, is de-

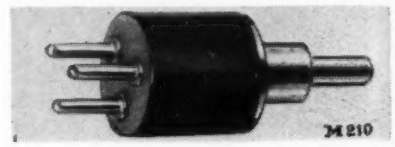


signed for rugged service in aircraft, missiles, etc. Power source 28 vdc; film capacity 200 ft (100-ft model also available). Can be pulsed electrically or manually at speeds to 10 frames per second. Cine operation at 16 frames per second.—*Vought Co., Box* 1350, *Beverly Hills, Calif.*

For more information circle **428** on inquiry card.

PLUG-IN VDRs

New "Model APP-½" precision voltage-dividing resistor is provided with a 3-prong base that fits stand-

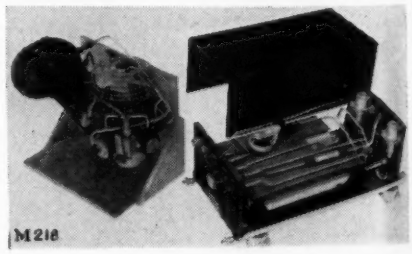


ard 3-circuit microphone sockets: simplifies installation in miniaturized printed-circuit or automated assemblies where precise positioning and rapid installation are essential. Available in resistance range of 10 to 100,000 ohms.—*Waters Mfg, Inc., P. O. Box* 368, *South Sudbury, Mass.*

For more information circle **429** on inquiry card.

MILITARY CRYOSTAT

New "Model 196" cryostat system, engineered specifically for military applications, is an extremely light-

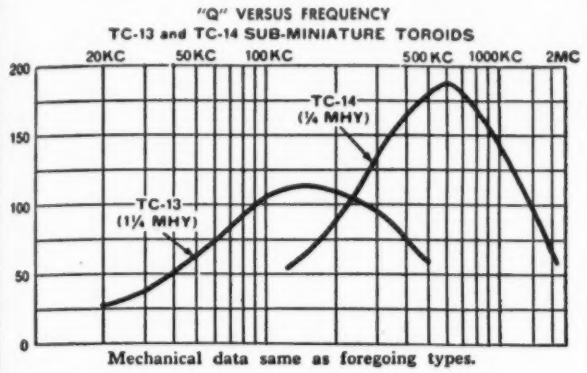


weight instrument designed to meet JAN specs, packaged for airborne installations and operating from a 28-vdc power source. System consists of three parts: pump assembly, regulator assembly, and cooling head. Cooling heads with heat pumping capacities of 1.5 to 5 watts are available to fit wide range of sizes and shapes of re-entrant Dewar detector units.—*Perkin-Elmer Corp., Norwalk, Conn.*

For more information circle **430** on inquiry card.

Toroids

The merits of the toroidal type winding coupled with the numerous advantages of the molybdenum permalloy dust core represent the optimum in coil characteristics for audio applications. These toroids provide higher Q, greater stability of inductance vs.



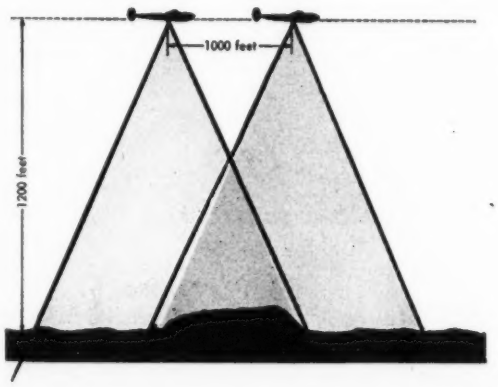
Mechanical data same as foregoing types.

temperature and level in a smaller space than any other available structure . . . Coils are supplied to an inductance accuracy of 1% . . . Most useful frequency range of the subminiature Type TC-13 is between 40 and 400 kc. Available up to 100 mhys with optimum characteristics below 10 mhys.—(*From new 16-page Cat. No. 103, Burnell & Co., Inc., 45 Warburton Ave., Yonkers 2, N. Y.*)

For this literature circle **307** on inquiry card.

Aerial Survey

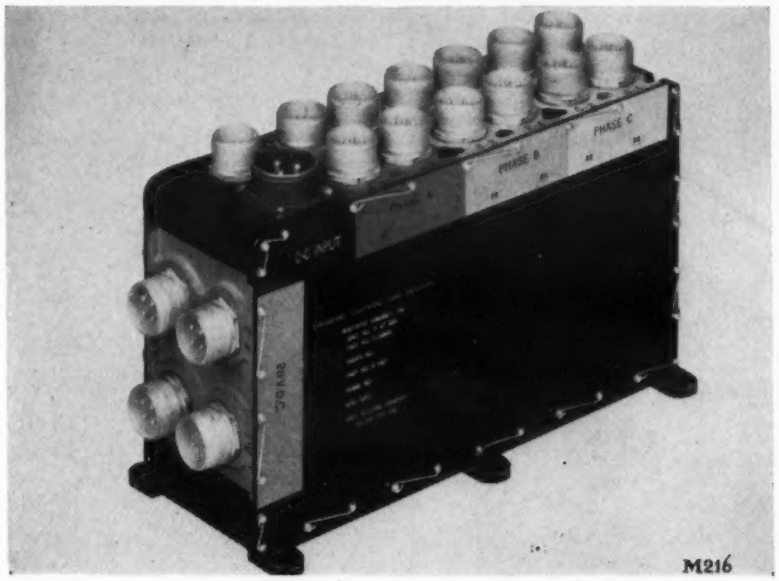
Unlike the days of World War I, when pilots first became aerial photographers by photographing the enemy's strong points, today's aerial surveys are precision studies.



By snapping photographs from two different angles and projecting them onto a single screen it is possible for lab technicians to produce a three-dimensional effect. With the aid of costly machinery, lines of equal elevation can be traced, providing contour maps accurate to 1′. (*From 30-page issue of "New Frontiers" (Vol. IV, No. 2), Charles H. Hansen, Publications Mgr., The Garrett Corp., 9851 Sepulveda Blvd., Los Angeles 45, Calif.*)

For this literature circle **308** on inquiry card.

MINIATURE ELECTRIC SUBSTATION FOR MISSILE



New airborne metal-clad electrical switching equipment (developed for use in USAF SM-62 Northrop Snark intercontinental guided missile) transfers 88 electric circuits and 7 signal circuits from ground test power to airborne power in 2½ seconds. Operated by remote control, unit provides instantaneous synchronization, make before break, assuring a constant power supply. Replacing a unit weighing several hundred pounds, it weighs 28 lbs. It eliminates relays, coils, cores, magnetic armatures and vacuum tubes, and also eliminates check-off circuits and equipment from being airborne in missile. Drawing only 6.2 amp at 28 v for 2.5 sec maximum, total energy used is only 434 watt-seconds, replacing the continuous load of a large group of relays. It provides 22 contactors per phase (a total of sixty-six 400-cycle contacts sp-dt), also 7 signal circuits sp-dt.—*Cole Electric Co., 8439 Steller Drive, Culver City, Calif.*

For more information circle **431** on inquiry card.

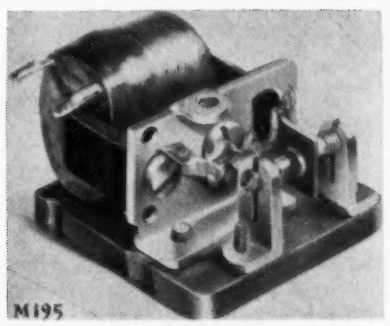
DIRECTION FINDER

New lightweight automatic direction finder system for use in aircraft weighs less than 30 lb including cables (currently-used equipment weighs 80 lb). New loop antenna, electrically interchangeable with AS-313B, has been streamlined to the extent that it protrudes only 2½" from fuselage and readily permits flush mounting. System operates from any radio signal between 190 and 1750 kc and automatically displays compass bearing of received signal with respect to aircraft heading. System's radio set serves also as a communications receiver. System has satisfactorily passed rigid operational and environmental test programs.—*Magnavox Co., Fort Wayne 4, Ind.*

For more information circle **432** on inquiry card.

SENSITIVE RELAYS

New "Series R" sensitive relays meet MIL-R-5757B; operate on as low as 0.5-w coil power with transit times as low as 3.5 milliseconds. Contact capacity 1.5 amp inductive at 200 v ac or dc. Adjustable contacts normally set for pull-in current of 7.2 ma maximum and drop-in current of 4.8 ma minimum; can be adjusted for other values. Unit pictured is sp-st open type; is also available in dp-dt or in tandem (two relays on one base). Also available hermetically sealed. Coil value 5000 ohms for nominal 30 vdc operation. Life exceeds 220 million operations.—*Redar Relay, Inc., 2120 Pontius Ave., Los Angeles 25, Calif.*



For more information circle **433** on inquiry card.

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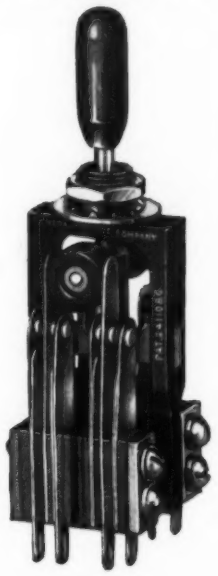

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For more information circle **25** on inquiry card.

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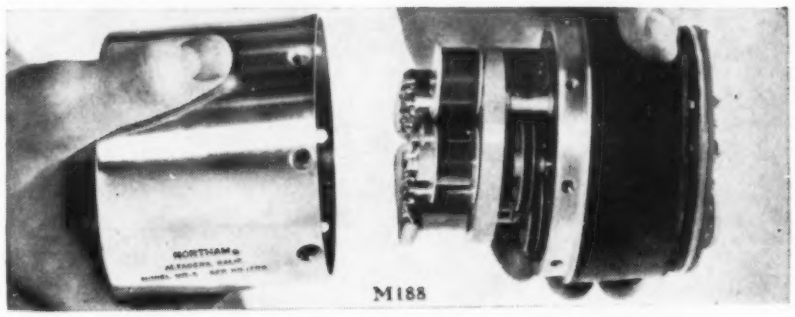
New Products–*Cont.*



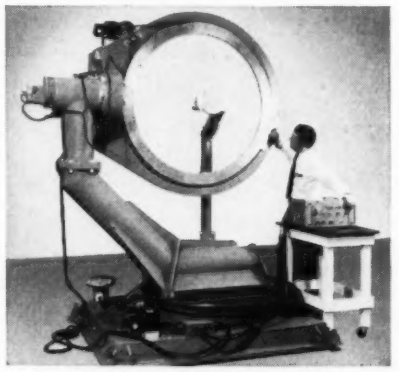
MINIATURE TAPE RECORDER FOR MISSILES

New 2½-lb "Model MR-5" has solved problem of collecting flight test data from missiles too small for telemetering equipment. Principal use: recording skin temperatures during critical periods of high-speed high-altitude flights. Ruggedness and shock resistance: a "Model MR-5" has been recovered and re-used eight times in HTV tests at Holloman Air Development Center, whereas telemetering equipment shatters upon initial ground impact.—*North American Instruments, Inc., Altadena, Calif.*

For more information circle **434** on inquiry card.

RADOME TESTING SYSTEM

New "Model 150 Radome Boresight-Error Measuring System" automatically records beam deflection as a

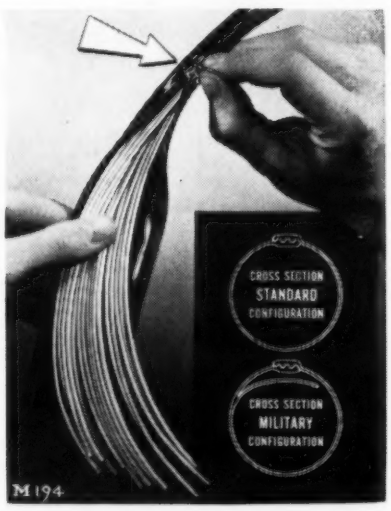


continuous function of radome position; requires far less time than (and does not miss discontinuities often overlooked by) manual point-by-point measurements. Operation: a transmitting parabola on end of Null-Seeking Boom directs a pencil beam at radome and receiving antenna located at the other end of a 1500" range. Received signal, by means of a servo system, positions Null-Seeking Boom to apparent axis of receiving antenna as seen through deflecting radome. While motor driven Radome Holding Fixture (pictured) rotates, three recorders, synchronized with position of the radome, plot magnitude and horizontal and vertical components of beam deflection angle as represented by the position of Null-Seeking Boom.—*California Technical Industries, 1464 Old County Rd., Belmont, Calif.*

For more information circle **435** on inquiry card.

ZIPPERED PLASTIC TUBING

New zipper-style plastic tubing, "Zippertubing," minimizes time and costs in lacing and tying electrical



harness assemblies; effectively encloses, identifies and protects multi-conductor wiring; also finds many applications such as wiring ducts, wire marking (in short lengths), and as a replaceable cable jacket to protect expensive custom cables from abrasive wear. Zipper pull-tab is detachable. Tubing can be "unzipped" and re-used, or permanently sealed with a sealer provided by maker. Available in nine colors, including black and clear plastic, material meets MIL-I-631B and MIL-I-7444A. ID's from ½" to 4½" in increments of ⅛" Wall thicknesses 0.020" and 0.040". Available in continuous lengths from 20 to 1,000 ft.—*W. A. Plummer Mfg. Co., 752 S. San Pedro St., Los Angeles, Calif.*

For more information circle **436** on inquiry card.

PREFABRICATED OPEN-WIRE H-F TRANSMISSION LINE

New prefabricated high frequency open-wire transmission line is commercially available for the first time in a variety of sizes to meet exacting impedance and capacitance requirements in temperatures from -60°F to 60°F. It is catalogued under military specifications.—*Fretco Inc., 406 N. Craig St., Pittsburgh 13, Pa.*

For more information circle **440** on inquiry card.

SHOCK-MOUNTED CRYSTAL

New "Model St 70X" crystal unit for missiles, etc., frequency range 200-500 kc, meets shock test of 100 *G*, withstands vibrations of 15 *G*, 10 to 55 cps for 2 hr; 5 *G*, 5 to 500 cps for 45 min; 3 *G*, 500 to 1200 cps. Operable temperature range —55°C to 120°C. Frequency excursion as low as ±0.001% over any given 30 C° temperature range.—*Bulova Watch Co., Electronics Div., 40-06 62nd St., Woodside 77, N. Y.*

For more information circle **437** on inquiry card.

BROADBAND SILICON CRYSTAL

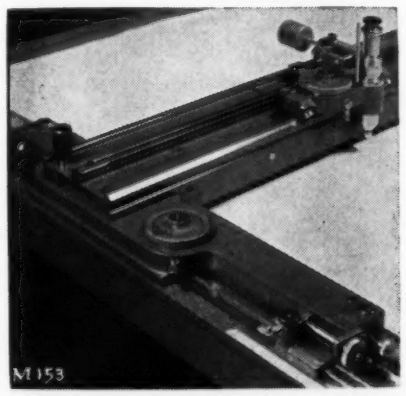
New "MA-412" extremely broadband millimeter waveguide crystal, suitable for mixer or low-level video

detector use in range of 26.5 to 75 kMc, is a silicon diode said to be "the first truly broadband millimeter waveguide crystal commercially available for military and industrial applications." It is cased in silver-plated brass; case forms a section of ridged waveguide with crystal as an integral part; can be adapted for high-sensitivity broadband performance in standard rectangular waveguide applications, or for broadband ridged waveguide.—*Microwave Associates, Inc., 22 Cummington St., Boston 15, Mass.*

For more information circle **438** on inquiry card.

PLOTTING INSTRUMENT

New "Coordinatograph" plots points along *X* and *Y* coordinates within 0.001"; is suitable for aircraft



lofting, gage charts, and laying out small parts; also to establish coordinate positions precisely for chart and map makers, and to plot reticles or targets for instrument makers. Working area 47½" x 47½"; radii from 12" to 40" can be plotted. Pricker point unit has a 7-power microscope, so that point can be observed and plotted in a single set-up.—*Aero Service Corp., 210 E. Courtland St., Philadelphia 20, Pa.*

For more information circle **439** on inquiry card.

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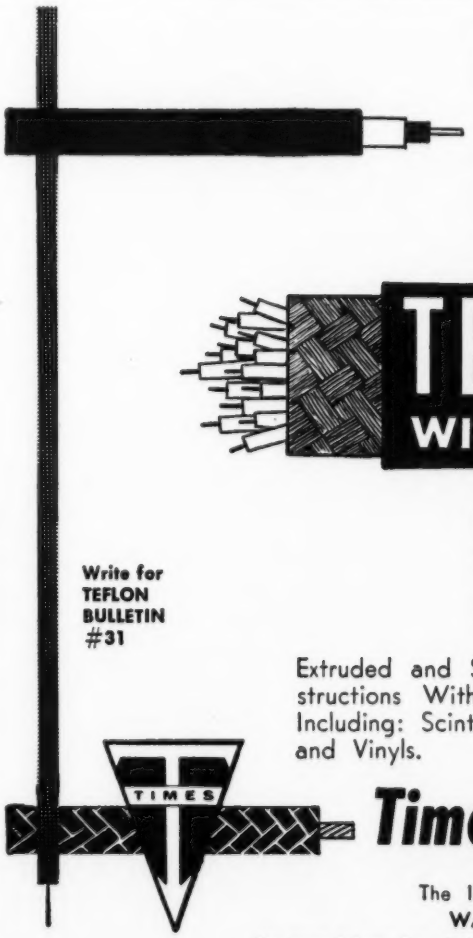
For more information circle **26** on inquiry card.



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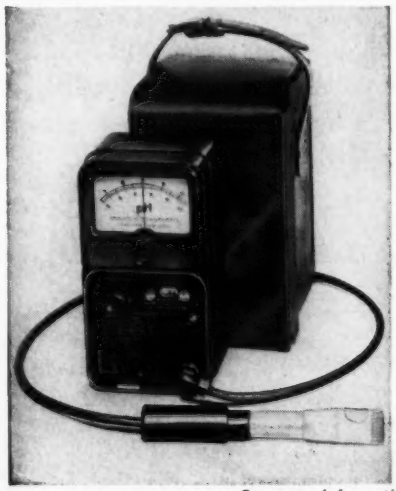

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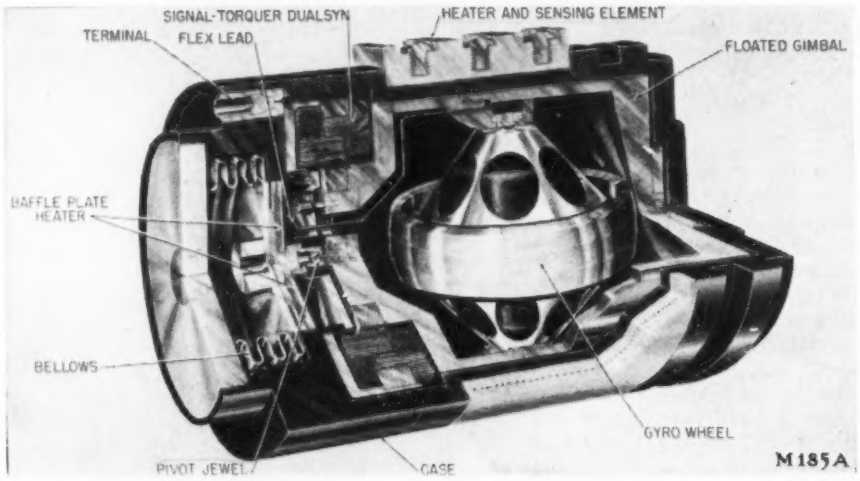
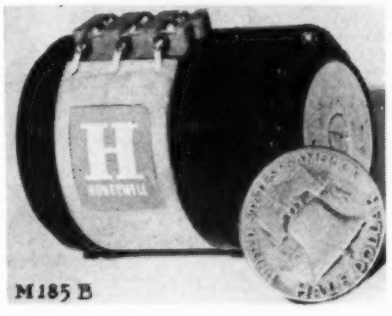
For more information circle **28** on inquiry card.

New Products—*Cont.*

MINIATURE "FLOATED" GYROSCOPE





New "MIG" (miniature integrating gyroscope) weighs less than 8 oz, yet will meet low-drift-rate requirements of short-time or "aided" automatic guidance systems. It has the angular momentum of a HIG-5 (10^5 gm-cm²/sec) and performance comparable to larger HIG's under unfavorable environments. Among new design concepts: (1) combining signal and torque generators into a single dual-microsyn (called "Dualsyn") placing it at one end of case with gimbal at the other; (2) reduction of gimbal suspension pivot to 0.016"; (3) new method of fluid fill that virtually eliminates balance-shifting air bubbles; (4) new isoelastic spinmotor and mounting structure that greatly improves performance under vibration; (5) improved end bellows that allows flotation fluid changes over a wide range of internal temperatures. —*Minneapolis-Honeywell Regulator Co., Aeronautical Div., Philadelphia 44, Pa.*

For more information circle **441** on inquiry card.

COMPACT WIDE ANGLE LENS

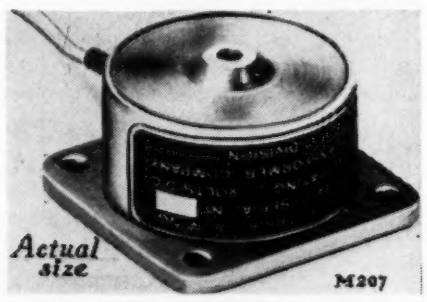
New "720" is said to be "the most compact 3.45 mm wide-angle lens that is available in the instrumentation

field," covers 165° both horizontally and vertically; is available either in a gun camera (GSAP) or a "C" mount; comes equipped with an iris ring adjustment from f/1.5 to f/8.0; is believed to be the only lens of this type commercially available.—*Traid Corp., 17136 Ventura Blvd., Encino, Calif.*

For more information circle **442** on inquiry card.

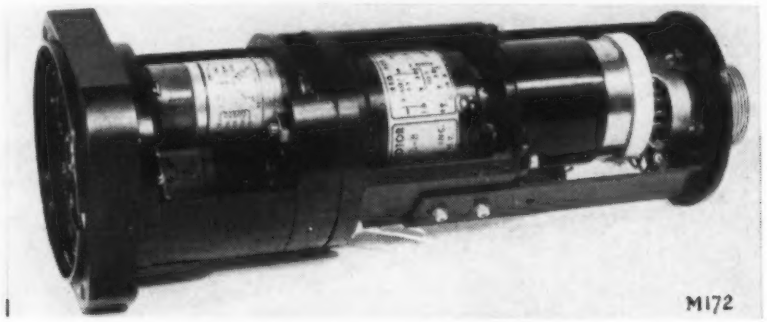
ARMING SOLENOIDS

New "Type PA-1193" arming solenoids are extremely compact high-efficiency aircraft units. Arming pin



projects when solenoid is energized (15.5-28 vdc) and will support a 100-lb ring-hung load. When solenoid is de-energized, pin retracts under a 5-lb ring-hung load. "PA-1193" meets MIL-S-4040A and MIL-E-5272A.—*United Transformer Corp., Pacific Div., 4008 W. Jefferson Blvd., Los Angeles 16, Calif.*

For more information circle **443** on inquiry card.



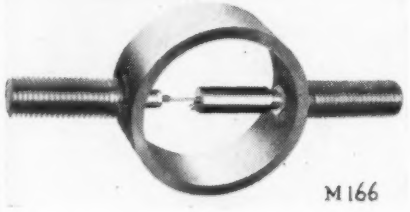
SERVO-TYPE DATA REPEATERS

New servo-type data repeaters provide remote indication of angular position and of ac and dc voltages; mount in standard aircraft panels with output dials arranged for visual observation or photographic recording. First of two basic types is "Synchro-Data Repeater" two-speed follow-up servo employing standard Bu-Ord Mk 54 Mod 2 synchro transmitters; available with four different speed ratios between synchros. Second basic type is "Potentiometer-Data Repeater" position servo utilizing a precision ten-turn "Helipot" as follow-up transducer and designed to employ same type "Helipot" for input transmitter; one model for ac and one for dc voltage data.—*Feedback Controls, Inc., 907 Main St., Waltham 54, Mass.*

For more information circle **444** on inquiry card.

FORCE OR LOAD PICKUPS

New line of force or load pickups utilizes variable-permeance rectilinear transducers which are less affected by temperature changes than linear variable differential transformers or strain gages. Repeatability is nearly 100% and resolution is limited only by external circuitry. When new pickup is used with maker's "Model 67 Control System," full-scale readout can be set for less than one-tenth of pickup's full range. Thus one instrument can be used for many different force or load ranges. New pickup senses either compression or tension force without mechanical adjustment.—*Crescent Engineering & Research Co., 5440 N. Peck Rd., El Monte, Calif.*



For more information circle **445** on inquiry card.

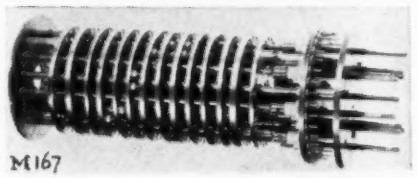
400-CPS DC POWER SUPPLY

New "Model ECR950S selenium full-wave rectifier meets standard MIL specs for shock, fungus, humidity and temperature, provides constant voltage supply for filaments, relays and lab supply, has a dc output rating of 6 to 9v and 0 to 50 amp with an ac input of 105-125v single-phase 360-440 cps. Regulation 0.2% at fixed load with line change of 105 to 125v or at fixed line voltage with load change from 5 to 50 amp. Recovery time about 0.2 sec; ripple 0.5% rms at 400 cps input. Panel type cabinet with open construction is constructed of aluminum and is supplied with lifting handles.—*Richardson-Allen Corp., 116-15 15th Ave., College Point, N. Y.*

For more information circle **446** on inquiry card.

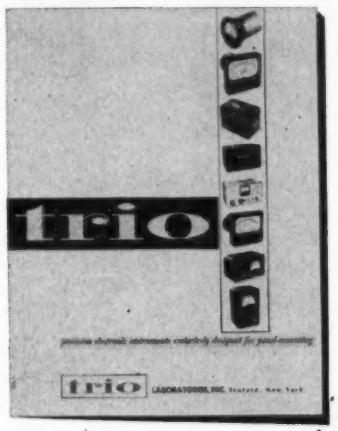
PRECISION DELAY LINE

New delay line especially developed for aviation use is based on the magnetrostrictive properties of nickel. In it, a number of spaced impulses are generated from a single pulse and fed into a crystal matrix. By suitably biasing individual crystals, a pulse code can be obtained. Fifteen pickup coils are precisely positioned by micrometic screws. Resulting pulses have stability of position in time to 0.05 usec. Weight is less than 1.5 lbs. ★All-purpose "Model 103" magnetrostrictive-type delay line provides infinite time-delay settings by means of individual pickup coils positioned and locked in place along slotted and calibrated microsecond delay scale.—*Deltime, Inc., 608 Fayette Ave., Mamaroneck, N. Y.*



For more information circle **447** on inquiry card.

free engineering guide tells you how to design-in panel-mounting miniature electronic instruments



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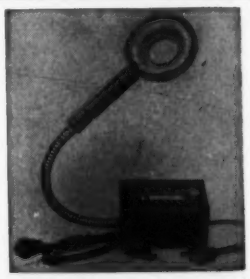
NEW Mic-O-Lite for Shadowless Illumination in



• Inspection • Investigation • Research

Mic-O-Lite is a cold light ring source designed especially to produce *"shadowless"* illumination on small objects, parts or specimens. It is an ideal source for visual inspection under magnification, but is primarily designed for low power microscopic inspection and photography in the industrial, scientific and research fields.
Mic-O-Lite features a "ring light" 2½" in diameter. A doughnut type aluminum reflector which snaps onto the lamp provides a 1¼" aperture in the center through which the microscope or camera lens is focused.
A variety of interchangeable lamps including warm white, daylight white, blue, "Black Light" and germicidal are available.

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Special cold cathode shapes and colors fabricated to specification for scientific and industrial applications. Spectral energy may be matched to photo cell sensitivities where required. Inquiries invited.

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For more information circle **30** on inquiry card.

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Start to finish engineering of instrumentation systems for automatic control of processes is offered through Panellit Service Corporation. This staff of mechanical, electrical and chemical engineers — all with process experience — offers the broad scope of services outlined below.

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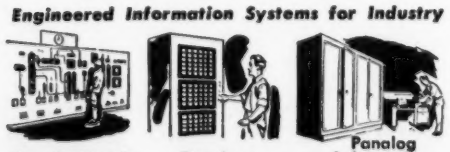

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For more information circle **31** on inquiry card.

New Products—*continued*

AIRCRAFT CONTROL AMPLIFIER

New 11-oz control amplifier regulates power for the entire fire-control system of a military airplane when used with appropriate voltage reference, resistive divider network and transistor. Adaptable to voltages from approximately ±50v to ±1000v, unit provides an overall circuit gain of 60 to 80 db, reduces ripple to less than 50 mv peak-to-peak, and operates within a temperature range 65° to 125°C, with life expectancy of 10,000 hours, or more.—*Technical Products Div., Packard Bell Electronics Corp., Los Angeles, Calif.*

For more information circle **448** on inquiry card.

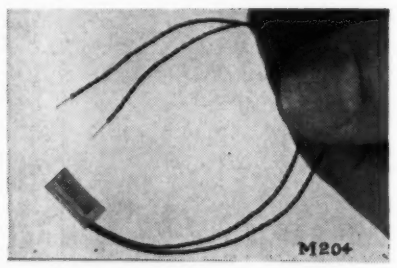
RATE GYRO FOR MISSILES

New "Series RG 03-0100," for missile applications having severe shock and vibration requirements, has conventional spin axis orientation to permit easy interchangeability with other gyros. Production units of this series have been qualified to missile specs more severe than MIL-E-527A. Maker's exclusive wheel-and-gimbal system obviates use of pivots, bearings or loose springs; permits use of a standard miniature motor and avoids loading of gimbal with motor's static mass. Standard pickoff 5000 ohms with power dissipation to 1w; resolution 0.35%; linearity 1%; hysteresis 0.5%; angular momentum 250,000 cgs units. Available ranges ±10°/sec to ±800°/sec. Motor 115 v 400 cps, 1 or 3-phase.—*Humphrey Inc., 2805 Canon St., San Diego 6, Calif.*

For more information circle **449** on inquiry card.

TINY SURFACE-TEMPERATURE RESISTANCE ELEMENTS

New "Type 1371" of maker's "Tape-On" surface temperature resistors are for temperature telemetering; can be applied to any surface in seconds by pressing thumb over a small piece of Mylar tape, and they can be used directly in a commutation circuit to modulate standard telemetering transmitters. Resistance change over specified temperature range being 100 ohms, they can be added to an installation using other Trans-Sonics thermometric elements without further circuitry modification. Available in various ranges between limits of −300°F and 400°F. —*Trans-Sonics, Inc., Box 328, Lexington 73, Mass.*



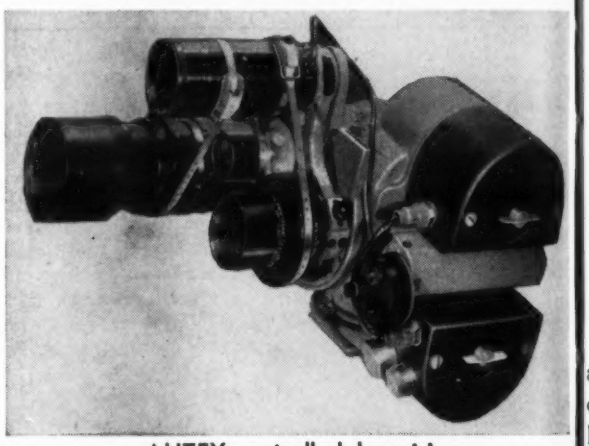
For more information circle **450** on inquiry card.

Automatic Exposure Control

Automatically, instantaneously, continuously . . . AUTEX, the Flight Research Automatic Exposure Control, adjusts the aperture setting of any motion picture camera to maintain perfect film exposure under varying conditions of light . . . and where film sequences **must** be recorded without the possibility of a re-take. Simple to use, AUTEX takes the unexpected into account and eliminates "compromised frames."

The basic objective . . . to provide an accurate and easily used camera accessory which can be adapted to any camera and to most lenses . . . by combining an advanced transistor circuit with the latest in printed circuit techniques. The adaptability . . . achieved by using an adjustable tape drive.

Here's how AUTEX works. A change in photocell voltage caused by a change in light level trips a small, but rugged, relay. A unique transistor-relay circuit developed especially for AUTEX controls the drive motor. The motor rotates the head so that the flexible tape drives the lens iris ring in the proper direction to correct for the change in light level. A balancing potentiometer in the head "feeds back" the lens setting to the circuit so that the relay opens and the motor stops when the lens is set properly for the new light conditions.



AUTEX-controlled lens iris

The circuit is electrically matched to various lenses by setting the lens dial. Setting for different film speeds and different exposure times is easily set on the base scale on the control head. The ACCENT CONTROL permits instant compensation during filming of high contrast scenes where the object of interest is brighter or darker than the average scene brightness.

The unusual sensitivity of AUTEX allows full advantage to be taken of high speed films and lenses using "available light" techniques which are necessary in many situations in scientific, news, and documentary photography. (*From new 6-page Bulletin, Flight Research Inc., P. O. Box 1-F, Richmond 1, Va.*)

For more information circle **309** on inquiry card.

Analog Computer Components

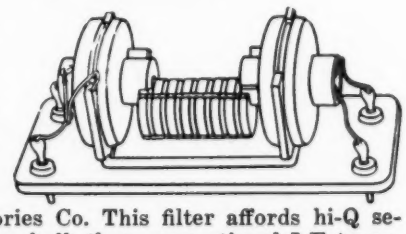
The new K3 series of Analog Computing Components is a modular family of operational blocks, both linear and nonlinear, which allow rapid set-up of the problem with minimum knowledge of electronic circuitry. Each component is a self-contained operational unit, engineered for functional efficiency in a computing system. The user of a K3 installation goes directly from a block diagram of the problem-to-be-solved or system-to-be-simulated to the correct arrangement and interconnection of the computing components, to set up a dynamic analog model. Solutions may be displayed on an oscilloscope screen. Linear components (K3-A, C, D, E, J, K, and L) provide both positive and negative outputs which may be used simultaneously. Inputs and outputs may range from −50 to +50 volts. Clearly-visible lamps denote outputs in excess of 50 volts. (*From 16-page brochure "GAP/R Electronic Analog Computers," George A. Philbrick Researches, Inc., 230 Congress St., Boston 10, Mass.*)

MODEL	EQUATION
K3-A Adding Component	$\pm e_o = e_1 + e_2 + e_3 + e_4 + E$
K3-C Coefficient Component	$\pm e_o = Ce_i$
K3-D Differentiating Component	$\pm e_o = aT\frac{de_i}{dt}$
K3-E Augmenting Differentiator	$\pm e_o = e_i + aT\frac{de_i}{dt}$
K3-J Integrating Component	$\pm e_o = \frac{1}{T}\int e_i dt$
K3-K Augmenting Integrator	$\pm e_o = e_i + \frac{1}{aT}\int e_i dt$
K3-L Unit-Lag Component	$e_o + aT\frac{de_o}{dt} = \pm e_i$
K3-5 Connecting Jack-Box	None

e_o=output voltage; e_1, e_1, e_2, e_3, e_4 represent input voltages.

For more information circle **310** on inquiry card.

I-F FILTER UNITS

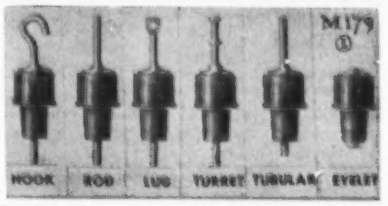


New Collins Radio Co.'s magnetostrictive filter unit will now be sold thru its subsidiary, The Communications Accessories Co. This filter affords hi-Q selectivity with less bulk than conventional I-F transformers from 60 cps to 600 kc. Fixed-tuned, variable selectivity is obtained by switching two or more filters.—*Communication Accessories Co., Hickman Mills, Mo.*

For more information circle **451** on inquiry card.

HERMETIC SEAL TERMINALS

New "Type LT" miniature units, for superior hermetic sealing of all types of electrical components, are

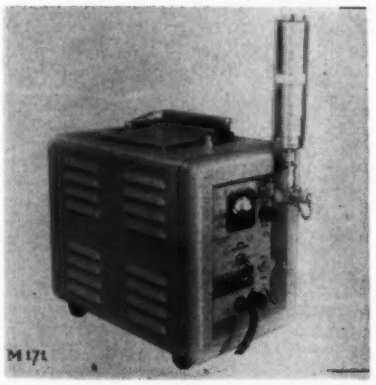


designed to meet all military and commercial application requirements. Molded fluorocarbon plastic body insulates solder seal ring from feed-through lead. Units are unaffected by high humidity; are chemically inert to organic solvents, acids, alkalies, oils and fumes; withstand usual production handling and will not crack or craze.—*International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa.*

For more information circle **452** on inquiry card.

TACAN TEST SET

New "Type FTR 3156" portable test set permits rapid ground testing of airborne TACAN (Tactical Air



Navigation) receiver-transmitter equipment while this equipment remains undisturbed in the plane; can be used with either military airborne TACAN (AN/ARM-21) or with Federal's commercial version.—*Federal Telephone & Radio Co., 100 Kingsland Rd., Clifton, N. J.*

For more information circle **453** on inquiry card.

AIRCRAFT AUTOFORMERS

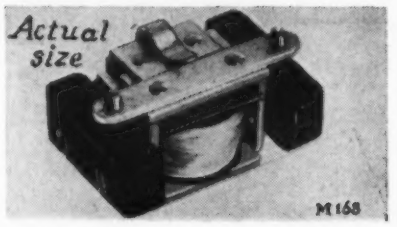
New "Vari-Lite" aircraft variable autoformers are designed to replace resistive-type control units with high-

efficiency controls of exceptional reliability. Input is 115 v 400 cps; output is 0 to 28 v. Illustrated unit is "PA-1028," 4-amp capacity, weight 19 oz. It meets MIL-T-9219 and MIL-E-5272A.—*United Transformer Corp., Pacific Div., 4008 W. Jefferson Blvd., Los Angeles 16, Calif.*

For more information circle **454** on inquiry card.

AIRCRAFT-COMPONENT RELAY

New precision sensing relay for aircraft component applications uses snap-action switches; features ac-

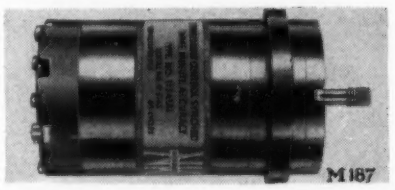


curate voltage sensing with controlled differential between operate and release voltages. Built only to customer specifications.—*Diaphlex Div., Cook Electric Co., 2700 Southport Ave., Chicago 14, Ill.*

For more information circle **455** on inquiry card.

3-MINUTE SYNCHROS

New 3-minute Size 23 Synchros meet all performance requirements and provide at least twice the accu-

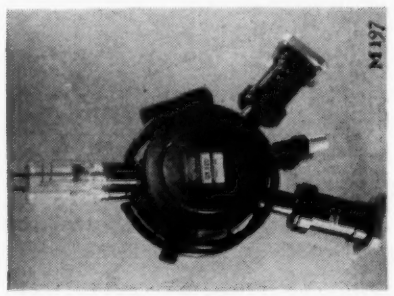


racy specified in FXS 1066, Rev. 4, Mil-S-16892 (BuOrd) and Mil-S-12472 (ORD). In many instances, they obviate need for two-speed synchro systems, thereby reducing cost and effecting appreciable economies in weight, size, complexity and gearing problems. Matched pairs are available to provide even greater system accuracy.—*Norden-Ketay Corp. Commerce Road, Stamford, Conn.*

For more information circle **456** on inquiry card.

MICROWAVE AMPLIFIER TUBE

New "Amplitron" high-power broadband microwave amplifier tube operates over a broad range of fre-

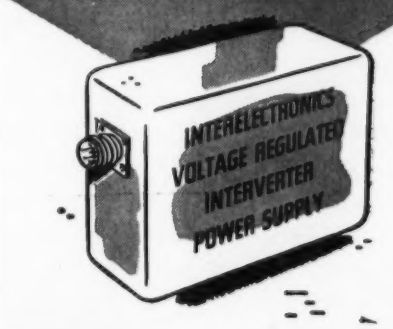


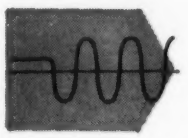
quencies without mechanical or electrical adjustments; can therefore be used as output stage of a high-power broadband chain; is "the only microwave tube that permits combined high-power, broadband, and coherent operation—three capabilities essential to advanced radar and countermeasures systems."—*Raytheon Mfg. Co., Microwave and Power Tube Operations, Waltham 54, Mass.*

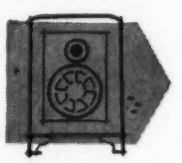
For more information circle **457** on inquiry card.

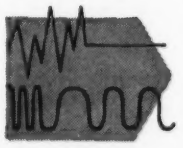
NEW!

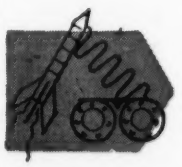
DC to DC and DC to AC solid-state power converters voltage regulated, frequency controlled, for missiles, telemetering, gyros, servos

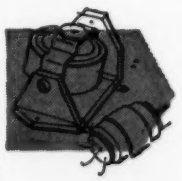












Interelectronics Interverter solid-state thyratron-like elements and magnetic components convert DC to any number of voltage regulated or controlled frequency AC or filtered DC outputs from 1 to 1800 watts. Light weight, compact, 90% or better conversion efficiency.

Ultra-reliable in operation, no moving parts, unharmed by shorting output or reversing input polarity. Complies with MIL specs for shock, acceleration, vibration, temperature, RF noise.

Now in use in major missiles, powering telemetering transmitters, radar beacons, electronic equipment. Single and polyphase AC output units now power airborne and marine missile gyros, synchros, servos, magnetic amplifiers.

Interelectronics — first and most experienced in the DC input solid-state power supply field, produces its own solid-state gating elements, all magnetic components, has the most complete facilities and know-how—has designed and delivered more working KVA than any other firm!

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For more information circle **32** on inquiry card.

MA EVENTS

May 9-10
Annual Meeting of the IRE Professional Group on Microwave Theory and Technique, Western Union Auditorium, New York City.

May 13-15
National Conference on Aeronautical Electronics, Dayton, Ohio.

May 20-22
Convention and Exposition, Armed Forces Communication & Electronics Association, Sheraton-Park Hotel, Washington, D. C. For information write William C. Copp & Associates, 1475 Broadway, New York 36, N. Y.

May 22-24
11th Annual American Society for Quality Control Exposition.

May 27-29
Third National Telemetering Conference, Hotel Cortez, El Paso, Tex. For information write J. M. Sherman, Exhibits Comm. Chairman, Electro-Mechanical Res., 4933 Mesa Rd., El Paso, Texas.

June 10-11
Second RETMA Symposium on Applied Reliability, Hotel Syracuse, Syracuse, N. Y. For information write J. A. Caffiaux, RETMA Eng. Office, Rm. 650, 11 W. 42nd St., New York 36, N. Y.

June 17-19
National Convention and Exhibit on Military Electronics (Missiles and Electronics) Sheraton Park Hotel, Washington, D.C. Sponsored by Professional Group on Military Electronics, Institute of Radio Engineers. For information write L. D. Whitelock, 5614 Greentree Rd., Bethesda 14, Md.

August 5-10
National Naval Aviation Meeting, sponsored by Institute of Aeronautical Sciences and its San Diego Section, U. S. Grant Hotel, San Diego, Calif.

August 20-23
Western Electronic Show and Convention, Cow Palace, San Francisco, Calif.

September 4-6
Second Technical Conference and Exhibit on Magnetic Amplifiers, Penn Sheraton, Pittsburgh, Pa. For information write David Feldman, Bell Telephone Labs., Whippany, N. J.

November 5-6
Joint Military Industry Guided Missile Reliability Symposium, Naval Air Missile Test Center, Pt. Mugu, Calif. (See page 70, this issue).

MA New Literature

ELECTRONIC COMPONENTS

ELECTRONIC COMPONENTS. New 8-page Catalog gives prices and illustrations and specs for end-of-run inventory clearance of electronic components.—Tripoli Electronics Co., 1949 West Erie St., Chicago 22, Ill.

Circle **501** on inquiry card.

PULSE TRANSFORMERS. New 2-page Bulletin 166T provides information on T Series pulse transformers wound on ferrite cores and cast in resin.—Technitrol Engineering Co., 1952 E. Allegheny Ave., Phila. 34, Pa.

Circle **502** on inquiry card.

PARABOLIC ANTENNAS. New 2-page Bulletin 436 provides specifications and features of the microwave and tropospheric scatter antennas.—Prodelin Inc., 307 Bergen Ave., Kearny, N. J.

Circle **503** on inquiry card.

DOUBLE STUB TUNER. New 2-page bulletin describes specs of double stub tuner for 1,000—12,000 Mc.—Uniwave, Inc., 2 Marine St., Farmingdale, N. Y.

Circle **504** on inquiry card.

ELECTRONIC COMPONENTS. New 48-page Catalog 571 describes and illustrates maker's audio transformers, discriminators, high-Q reactors, magnetic amplifiers, power components, pulse transformers, and ultrasonic components.—Freed Transformer Co., Inc., 1718-1736 Weirfield St., Brooklyn (Ridgewood) 27, New York.

Circle **505** on inquiry card.

PLUG-IN COMPONENTS. New 4-page Bulletin describes "Encapsors," maker's plug-in electronic circuit components, hermetically embedded in thermosetting plastic.—Alcor Electronics Corp., 180 Lafayette St., New York 13, N. Y.

Circle **506** on inquiry card.

INVERTERS AND CONVERTERS. New 16-page catalog presents maker's semi-conductor and transistorized inverters and converters.—Electronic Research Assocs., Inc., 67 East Centre St., Nutley 10, N. J.

Circle **507** on inquiry card.

ELECTRONIC COMPONENTS. Two new 2-page Catalogs 1157 and 1257 present maker's voltage supplies and ultra-sensitive electronic relays (including price list).—4-page illustrated price list presents surplus items, such as servo motors. generators, magnetic amplifiers, etc.—Servo-Tek Products Co., 1086 Goffle Rd., Hawthorne, N. J.

Circle **508** on inquiry card.

MAGNETIC AMPLIFIER. New 2-page Specification Sheet 57-907 gives mechanical and electrical specifications of operational magnetic amplifier Type MA-61.—Dynamics Research Associates, Div. of Universal Match Corp., P. O. Box 5841, Ferguson 21, Mo.

Circle **509** on inquiry card.

TRANSFORMERS. New 24-page Catalog 157-T lists maker's miniature hermetically-sealed inductive components, featuring the geophysical (very low frequency) type.—Electro-Tech Pacific, P. O. Box 455, Goleta, Calif.

Circle **510** on inquiry card.

MINIATURE PHOTOCONDUCTORS. New 8-page Bulletin TR-101 describes infrared-sensitive lead sulfide photoconductors for detection and guidance systems.—Electronics Corp. of America, Photoconductor Transistor Div., one Memorial Drive, Cambridge 42, Mass.

Circle **511** on inquiry card.

MAGNETIC AMPLIFIERS. New 6-page Bulletin S235B provides information on 60 cps, 400 cps magnetic amplifiers and magnetic amplifier position servo systems. New 4-page Bulletin 5418 presents servo demonstrator.—Magnetic Amplifiers, Inc., 632 Tinton Ave., New York 55, N. Y.

Circle **512** on inquiry card.

RELAY TERMS. New 18-page Bulletin 1884 gives definitions of relay terms and symbolic nomenclature excerpts from National Ass'n. of Relay Mfrs.—Automatic Electric Co., Northlake, Ill.

Circle **513** on inquiry card.

MICROWAVE ATTENUATOR. New 2-page Technical Bulletin Catalog 8201 describes high-power programmed microwave attenuator and power divider.—Airtron Inc., Linden, N. J.

Circle **514** on inquiry card.

EDDY CURRENT DAMPERS. New 2-page Bulletin 823 describes Eddy-Trol that damps out extraneous vibrations, restores feel to stick and prevents over-control movements. New 2-page Bulletin 824 presents hydraulic control valves for aircraft.—Lyndon Aircraft Corp., 140 Clifford St., Newark 5, N. J.

Circle **515** on inquiry card.

RELAYS. New 8-page Vibration Notebook (Vol. 3. No. 1) contains information on operation, design, and shock environments that are met in airborne instruments.—Allied Control Co., Inc., New York, N. Y.

Circle **516** on inquiry card.

TIME DELAY RELAY. New 4-page Bulletin SR-5R presents Model SF aircraft-type hermetically sealed time-delay relays.—A'G'A Div., Elastic Stop Nut Corp. of Amer., Elizabeth, N. J.

Circle **517** on inquiry card.

POTENTIOMETERS, RESISTORS

TRIMMER POTENTIOMETER. New 2-page Bulletin R-32B describes maker's new wire wound A10-W-Trimmer, ruggedized, for high temperature and humidity.—Dale Products, Inc., Columbus, Nebraska.

Circle **518** on inquiry card.

PRECISION POTENTIOMETERS. New 2-page Catalog B-2 contains complete data on maker's Series RL-270 precision potentiometers with unlimited phasing.—The Gamewell Co., Newton Upper Falls 64, Mass.

Circle **519** on inquiry card.

WIRE-WOUND RESISTORS. New 2-page Bulletin CB-2 describes maker's new Series CB precision wire-wound resistors featuring tension-free windings.—Kelvin Electric Co., 5907 Noble Ave., Van Nuys, Calif.

Circle **520** on inquiry card.

POTENTIOMETERS. New 12-page Technical Paper 762 provides information on environmental effects on precision potentiometers.—Helipot Technical Information Service, Newport Beach, Calif.

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METAL FILM RESISTORS. New 4-page Bulletin B-3 provides information and diagrams on maker's type MEC and MEF resistors incorporating metallic resistive films.—International Resistance Co., 401 North Broad St., Phila. 8, Pa.

Circle **522** on inquiry card.

POWER RESISTORS. New 4-page Bulletin 12 describes line of Vitrohm power resistors designed to meet requirements of MIL-R-26C (Fixed Wire-Wound Power Type Resistors).—Ward Leonard Electric Co., Mount Vernon, N. Y.

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CAMERAS

CAMERAS. New 8-page Brochure MC-2 contains information on Model IV-C, 35mm, and Model III, 16mm. Multidata cameras with data on their use in airborne systems analysis, radar evaluation and missile tracking.—Flight Research, Inc., P. O. Box 1-F, Richmond 1, Va.

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CAMERA LENSES. New 6-page brochure illustrates and describes Angenieux wide-angle Retrofocus lenses for 35-mm cameras.—Exakta Camera Co., 705 Bronx River Rd., Bronxville 8, N. Y.

Circle **525** on inquiry card.

PHOTOGRAPHIC DATA RECORDERS. New 4-page brochure illustrates 16 and 35 mm photographic data recorders for evaluation of missiles, aircraft and supersonic sled.—Vought Co., Box 1350, Beverly Hills, Calif.

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INSTRUMENTATION CAMERA. New 12-page brochure provides technical data and operating characteristics for

new TN-9 instrumentation camera available with automatic exposure control and special-purpose accessories.—Traid Corp., 17136 Ventura Blvd., Encino, Calif.

Circle **527** on inquiry card.

XEROGRAPHY. New 6-page Bulletin 1056 illustrates fully automatic reproductions from original documents or roll microfilm.—The Haloid Co., Rochester 3, N. Y.

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GYROS, MOTORS

RATE GYROSCOPES. New 4-page Brochure SA78-3 describes characteristic's of rate gyroscopes said to be world's smallest and lightest.—The United States Time Corp., 500 Fifth Ave., New York 36, N. Y.

Circle **529** on inquiry card.

GUIDANCE AND CONTROL. New 24-page catalog describes free gyros, rate gyros, linear and angular accelerometers, rectilinear and rotary potentiometers.—Humphrey Inc., 2805 Canon St., San Diego 6, Calif.

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GYROS. New 2-page Bulletin contains information on Model U-105—HIG 5 hermetically sealed single degree of freedom gyros with gimbal travel ±8° max. and drift rate 0.03 MR/sec.—Uniconn, Inc., Waterbury, Conn.

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SUBFRACTIONAL H-P MOTORS. New 4-page brochure on precision 60 and 400 cycle induction and synchronous motors for cooling fans and recording instruments, also servo motors with precision gear heads in a wide range of designs.—Rotating Components Inc., 267 Green St., Brooklyn 22, N. Y.

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TUBES, TRANSISTORS

VOLTAGE-TUNABLE MAGNETRON. New 16-page Bulletin ET-B40 provides engineering and application data on maker's Z-5040 voltage-tunable magnetron.—General Electric, Tube Dept., Schenectady 5, N. Y.

Circle **533** on inquiry card.

MICROWAVE TUBES. New 6-page bulletin provides information on maker's line of microwave tubes and components and development service.—Bomac Labs., Inc., Beverly, Mass.

Circle **534** on inquiry card.

SEMICONDUCTORS. New 6-page issue of New Parameter News (Vol. 1, No. 3) describes expanded, semiconductor line and presents semiconductor grade silicon now available.—Texas Instruments Inc., 6000 Lemmon Ave., Dallas 9, Texas.

Circle **535** on inquiry card.

VOLTAGE REGULATOR. New 2-page Bulletin 9.00.1 discusses maker's models STR-150 and STR-300 transistor-magnetic regulators for 400 cycle alternators.—Electric Regulator Corp., Norwalk, Conn.

Circle **536** on inquiry card.

TRANSFORMERS, CRTS ETC. New 8-page Bulletin 63 presents data on available pulse transformers, cathode ray tubes, lever switches, panel meters, etc.—Lectronic Research Labs., 715 Arch St., Philadelphia, 6, Pa.

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NAVIGATION

AIRCRAFT COMMUNICATION, NAVIGATION. New 4-page Catalog ARCBR-CC-1 describes communication and navigation transmitters and receivers, portable communicators and automatic direction finders for all classes of aircraft.—Aircraft Radio Corp., Boonton, New Jersey.

Circle **538** on inquiry card.

DEAD RECKONING TRACER. New 2-page Data Sheet TDS-5270 describes "Servo-flight" airborne automatic dead reckoning tracer for continuous automatic plotting of aircraft position.—Servo Corp. of America, New Hyde Park, N. Y.

Circle **539** on inquiry card.

AIR TRAFFIC CONTROL. New 4-page Brochure C-102 explains "Volscan" air terminal control system which automatically computes approach headings to expedite landing of stacked planes.—Avco Mfg., Co., Crosley Div., 1329 Arlington St., Cincinnati 25, Ohio.

Circle **540** on inquiry card.

ELECTRONIC INSTRUMENTS

MEMOSCOPE. New 4-page Bulletin 94-20 illustrates applications of maker's Memo-Scope that retains successive transients until intentionally erased.—Hughes Products, Memo-Scope, International Airport Station, Los Angeles 45, Calif.

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VOLTMETER. Two new 4-page Bulletins 325 and 7443 describe maker's ac-dc digital voltmeter and XY recorders, respectively.—Electro Instruments, Inc., 3794 Rosecrans St., San Diego, Calif.

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LOW-FREQUENCY CRYSTAL. New 2-page bulletin provides information on new Bulova ST-70X shock-mounted 200-500kc frequency control unit.—Quartz Crystal Div., Bulova Watch Co., Woodside 77, N. Y.

Circle **543** on inquiry card.

WWV AND WWVH. New 8-page Data File 10 describes function of new Model 905 WWV receiver and how to use standard time and frequency broadcast stations WWV and WWVH. Shasta Div., Beckman Instruments, Inc., P. O. Box 296, Station A., Richmond, Calif.

Circle **544** on inquiry card.

GENERATOR UNIT. 16-page May 1956 issue of General Radio's Experimenter presents a new (Type 1391-A) Pulse, Sweep, and Time-Delay Generator for time-dmain measurements.—New 8-page November 1956 issue presents Militarized line of autotransformers (voltage regulators).—General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

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AIRBORNE TAPE RECORDER. New 2-page data sheet discusses maker's airborne magnetic tape recorder designed for high-performance aircraft flight testing.—Midwestern Instruments, 41st. and Sheridan Rd., Tulsa, Okla.

Circle **546** on inquiry card.

INSTRUMENTS AND COMPONENTS. New 8-page Condensed Catalog illustrates and describes maker's precision measuring instruments, scientific apparatus, industrial test and control equipment and components.—General Radio Co., 275 Massachusetts Ave. Cambridge 39, Mass.

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MILITARY CIRCUIT ANALYZER. New 4-page bulletin describes Model 144 NX universal, automatic circuit analyzer for military use.—DIT-MCO, Inc., Electronics Div., 911 Broadway, Kansas, City, 5, Missouri.

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WIRE, CABLE

WIRE AND CABLE. New 70-page Catalog describes and illustrates new high-temperature surface treated Teflon insulated wire and cable.—Tensolite Insulated Wire Co., Inc., Tarrytown, N. Y.

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WIRES AND CABLES. New 6-page bulletin contains information on 24 types of plastic coated electronic and telephone wires and cables and special construction service.—Chester Cable Corp., Chester, N. Y.

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AVIONIC CABLE. New 2-page bulletin discusses color-coded flat cable up to 2" wide for missiles and aircraft.—Miljan, Inc., Paramount, Calif.

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CONNECTORS, CABLES. New 44-page Catalog 7 lists coaxial connectors, cable, plugs, jacks, waveguide, tubing, adapters, etc.—cross referenced with government designation and other manufacturers numbers, and coaxial cables characteristics.—Progress Electronics Co., 296 Broadway, New York 7, N. Y.

Circle **552** on inquiry card.

HOOK-UP WIRE. New 12-page Bulletin T257 provides catalog information including prices for hook-up and lead wire, insulated tubing and switches made to industrial and gov't specifications.—Birnbach Radio Company, Inc., 145 Hudson St., New York 13, N. Y.

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COMPUTING

LINEAR PROGRAMMING. New 6-page reprint provides information on linear programming on an electronic analog computer.—Reeves Instrument Corp., 215 East 91st St., New York 28, N. Y.

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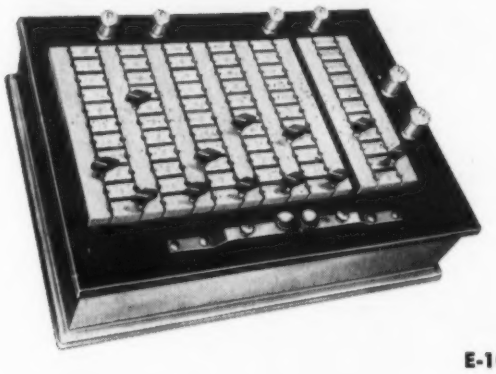

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Definitions

VHF *"Very high frequency"*—Any radio frequency between 30 and 300 megacycles.

VT *"Variable time"*—Used in combination only, as VT Fuze.

VAR *Visio-Aural VHF radio range*—A VHF radio range in which two separate signals are beamed in opposite directions for visual reception, and two additional signals beamed at right angles for aural reception and identification.

VOR *VHF Omnidirectional range*—may denote either (1) a phase shift omnidirectional range or (2) a rotating dual-pattern radio-frequency on-course signal. Both provide visual on-course indications, as well as true south or true north, by instruments in the cockpit.

SAGE *Semi Automatic Ground Environment*—Name for a defense system that provides instantaneous information needed for waging air battles, built about an electronic computer that reports and acts upon a developing situation.

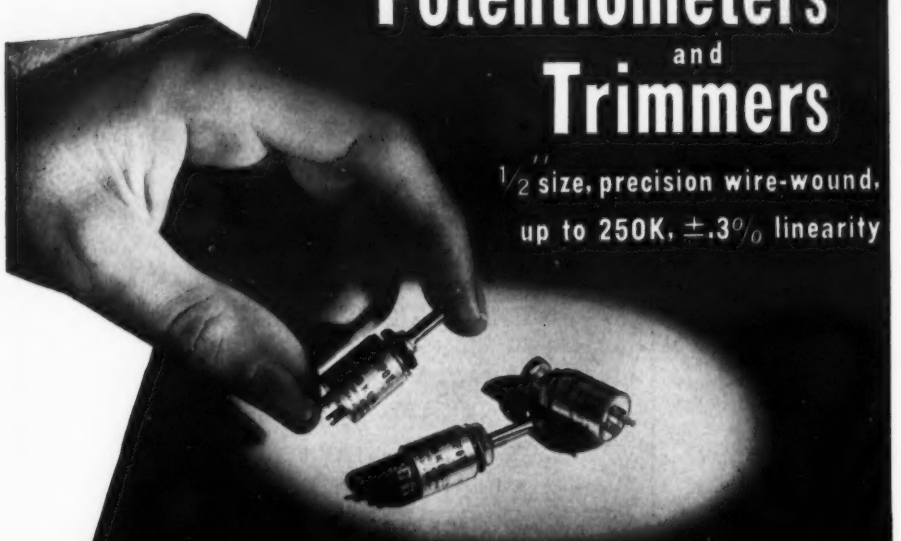
SAC Used alone, *Strategic Air Command*, U. S. Air Force. In combination only, *Supreme Allied Commander.*

SACLant *Supreme Allied Commander, Atlantic.*

*Adapted from many sources, including the *U.S. Air Force Dictionary*, Air University Press, for sale by Supt. of Documents, GPO, Wash. 25, D. C.

ACEPOT*
ACETRIM*

Sub-Miniature Potentiometers and Trimmers



1/2" size, precision wire-wound, up to 250K, ±.3% linearity

setting *new* standards for *dependability* in sub-miniaturization

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Condensed Engineering Data

	ACEPOT (potentiometer)	ACETRIM (trimmer)
Resistance Range	200 ~ to 250K ± 2%	10 ~ to 150K ± 3%
Linearity	±3%	±3%
Resolution	extremely high	excellent
Ambient Temperature	−55° C to 125° C*	−55° C to 125° C
Torque	low or high	low or high

The above specifications are standard — other values on special order.

Available in threaded bushing, servo, flush tapped hole or flange mounting, and ganged units. All units sealed, moistureproofed, and anti-fungus treated. Meet applicable portions of JAN specs and MIL-E-5272A standards.

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NEW LITERATURE

COMPUTER. New 4-page Application Report IH 106 describes how maker's general-purpose computer saved 2899 engineering manhours in solving typical problems of turbine data analysis.—Computer Div., Bendix Aviation Corp., 5630 Arbor Vitae St., Los Angeles 45, Calif.

Circle **555** on inquiry card.

LINEAR PROGRAMMING COMPUTERS. New 2-page Technical Data Sheet 113 describes maker's new "Reac LP 402-1 and LP 402-2" linear programming computers.—Reeves Instrument Corp., 215 E. 91st St., New York 28, N. Y.

Circle **556** on inquiry card.

SYSTEMS & FACILITIES

WEAPONS SYSTEM. New 20-page Catalog DCS5 discusses facilities for development of controls for modern weapons systems, including computers for ground control of ICBM, IRBM, data translation for SAGE, etc. Burroughs Corp., Detroit 32, Mich.

Circle **557** on inquiry card.

ELECTRONIC SYSTEMS. New 28-page Brochure 1-57 illustrates development and production facilities also typical projects undertaken by the Electronic Systems Div. for the Armed Forces.—Cook Electric Co., 2700 N. Southport Avenue, Chicago 14, Ill.

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SYSTEMS ENGINEERING. New 76-page Catalog No. 856-A provides information on company's electronic building blocks for systems engineering—Engineered Electronics Co., 506 East First St., Santa Ana, Calif.

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MISCELLANEOUS

HI-TEMP CLAMPS. Two new 2-page bulletins present data on maker's high-temperature (1500°F) cushion clamps.—TA Mfg. Corp., 4607 Alger St., Los Angeles 39, Calif.

Circle **560** on inquiry card.

AXIAL BLOWER. New 2-page data sheet presents maker's 4½" vane axial blower for high altitude.—Induction Motors Corp., 570 Main St., Westbury, L. I., N. Y.

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METAL BELLOWS SEALS. New 2-page bulletin describes new metal-bellows shaft seals designed to operate in excess of +700° F and lower than −100° F, for use in acids, solvents, etc.—Cartriseal Corp., 3515 W. Touhy Ave., Lincolnwood, Ill.

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THERMOSETTING POLYESTER. New 4-page bulletin contains information on properties of molding potting thermosetting polyester resins.—The Acme Wire Co., New Haven, Conn.

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HUMIDITY CHAMBER. New 2-page bulletin describes and illustrates maker's Blue M vapor-temp humidity chamber.—Blue M Electric Co., 138th and Chatham St., Blue Island, Ill.

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TEFLON. New 6-page Catalog and 2-page Data Sheet 357 provide data on Teflon tapes, insulators, bars, cylinders, rods, tubing, etc.—Enflo Corp., Route 38 at Airport Circle, Pennsauken, N. J.

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For further details concerning developments reported in advertisements, or New Product or New Literature reviews, CIRCLE THE NUMBER corresponding to that which appears with the ad or write-up. If the card has already been used, mark the number on a postal card (including month of issue) and send to us. When indicating change of address, kindly note old address.

Reader Inquiry Card

WALKIE-TALKIE. New 4-page Bulletin C-101 describes maker's mark 1 "Walkie-Talkie", a miniaturized, transistorized 8-lb climate proof communicator.—Avco Manufacturing Corp., Crosley Div., 1329 Arlington St., Cincinnati 25, Ohio.

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TEMPERATURE-SENSITIVE CRAYONS. New 6-page Catalog No. 551 provides information on maker's temperature-sensitive crayons, pellets and paints. New 8-page booklet "How Temperatures are Measured" discusses alternative techniques.—Tempil Corp., 132 West 22nd St., New York 11, N. Y.

Circle **567** on inquiry card.

FUEL BOOSTER PUMP. New 2-page Data Sheet 3-55 describes two-speed flush-mounted fuel booster pump designed for pumping fuel per MIL-F-5572 grade 115/145.—Lear, Inc., Lear-Romec Div., Elyria, Ohio.

Circle **568** on inquiry card.

THERMOCOUPLES. New 10-page Bulletin A is catalog of reciprocating engine thermocouples and terminals for aircraft.—Thermo Electric Co., Inc., Rochelle Park Post Office, Saddle Brook, N. J.

Circle **569** on inquiry card.

TRANSIT CASES. New 8-page brochure describes containers designed to protect cargo, such as guided missiles, electronic equipment and airplane parts during transit and storage.—Craig Systems, Inc., 90 Holten St., Danvers, Mass.

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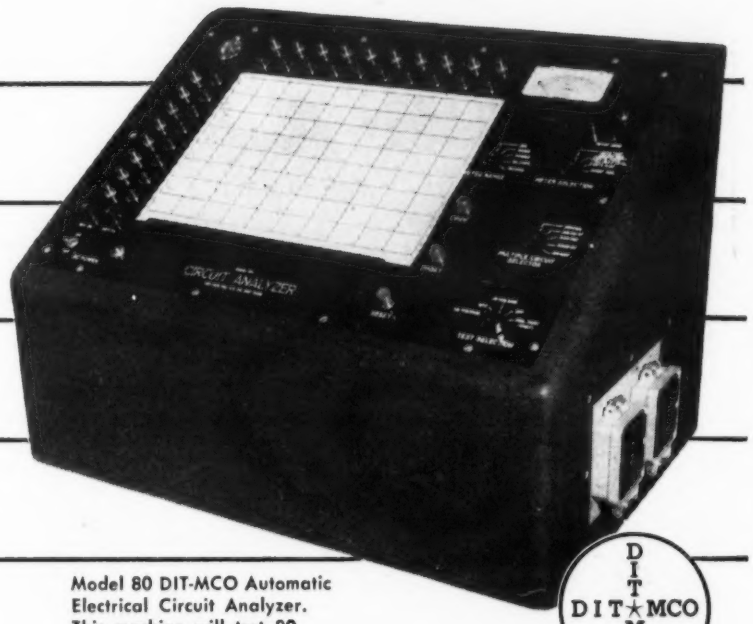

Model 80 DIT-MCO Automatic Electrical Circuit Analyzer. This machine will test 80 circuits in 8 seconds.

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In spite of its hairline accuracy and its ability to make fine measurements, the DIT-MCO Circuit Analyzer is a rugged, practically foolproof machine. Its component parts are the same as those used for years on automatic telephone systems, and most parts are pluggable. In laboratory tests, production line machines have been kept in operation for the equivalent of 10 years with no breakdowns at all.

The tremendous speed and accuracy of this machine plus its adaptability and capacity to test for all kinds of errors, make it a "must" for companies which manufacture, maintain, or overhaul products which include complex electrical circuitry. Basic sizes are built to test 80 to 200 circuits with multiplier sections to provide as much as 1600 circuits capacity.

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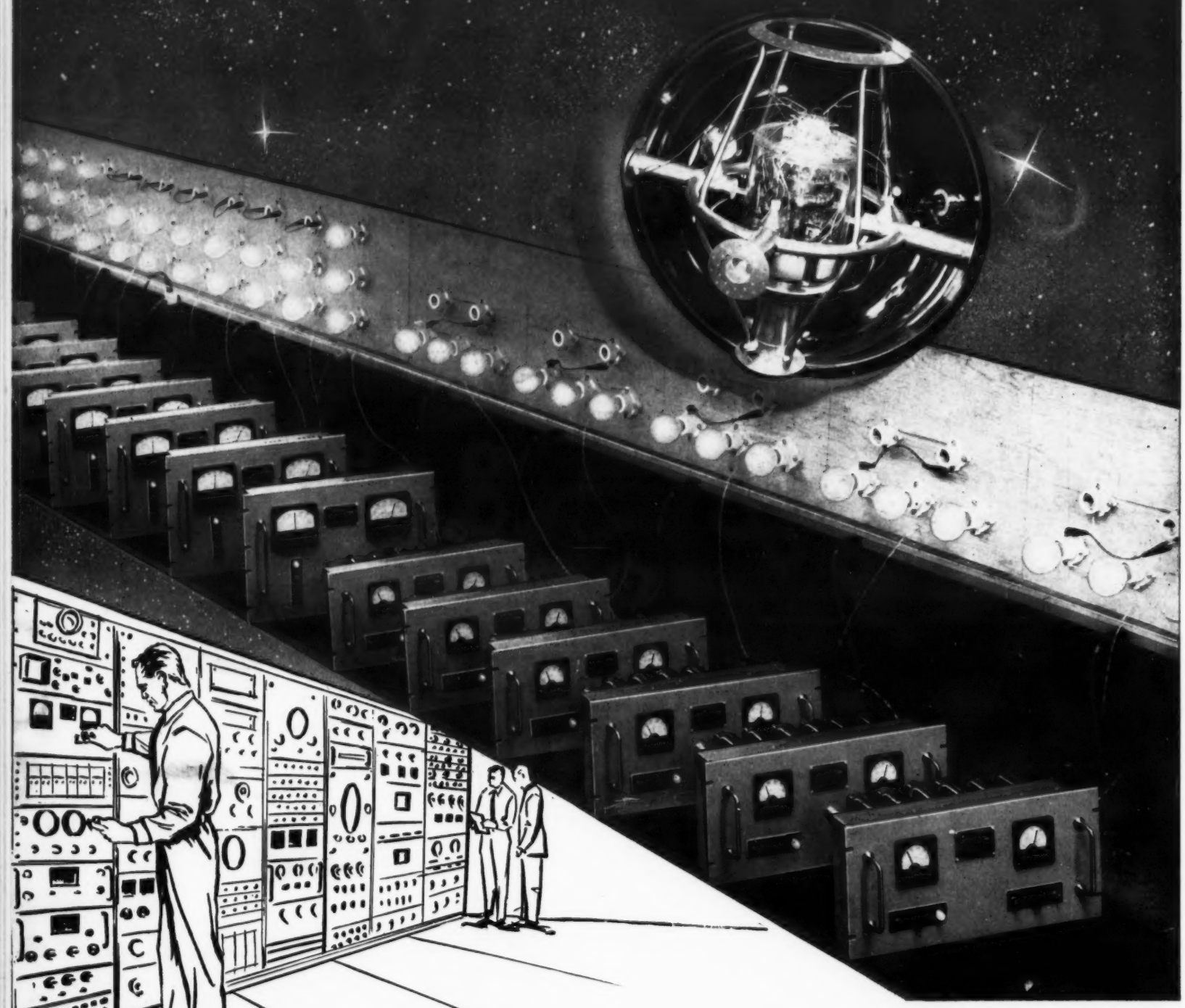

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